(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

CORRECTED VERSION

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
1 February 2001 (01.02.2001)

PCT

(10) International Publication Number
WO 01/007197 A1

(51) International Patent Classification[7]: B23K 26/02

(21) International Application Number: PCT/US00/17862

(22) International Filing Date: 24 July 2000 (24.07.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/359,230 22 July 1999 (22.07.1999) US

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(81) Designated States *(national)*: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *with amended claims*

Date of publication of the amended claims: 22 March 2001

(48) Date of publication of this corrected version:
25 July 2002

(15) Information about Correction:
see PCT Gazette No. 30/2002 of 25 July 2002. Section II

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 01/007197 A1

(54) Title: APPARATUSES AND METHODS FOR APPLYING AN INDELIBLE AND CONTRASTING PATTERN ONTO A CARRIER

(57) Abstract: Methods and apparatus are provided to apply permanent identification markings onto transparent carriers using laser induced vapor deposition technology. This is accomplished by vaporizing material from a marking media carried by a substrate using the heat generated from a laser and transferring the marking material onto a transparent carrier, the markings are dectectable using an optical reader or sensing device like x-ray, thermal imaging, ultrasound, magneto-optic, micro-power impulse radar, capacitance, or other similar sensing means.

APPARATUSES AND METHODS FOR APPLYING AN INDELIBLE AND CONTRASTING PATTERN ONTO A CARRIER

BACKGROUND OF THE INVENTION- FIELD OF APPLICATION

This present invention relates to the application of marks (human readable and /or machine readable) and other pattern configurations (stripes, symbols, etc.) to a substrate or other carrier; and, more particularly, to apparatuses and methods for the permanent application of such marks and/or other pattern configurations to a carrier.

BACKGROUND OF THE INVENTION-DESCRIPTION OF THE PRIOR ART

The placing of markings, such as human or machine readable alphanumeric characters or machine readable bar-codes or other symbology upon a carrier, such as an automobile license plate, credit card or similar item, for identification purposes, is not only common place today but there are numerous apparatuses and methods for accomplishing same. Similarly apparatuses and methods may be readily found for the application of lines and/or stripes and/or other configurations on such carriers. However it is quite difficult to find an apparatus and/or method to effectively and efficiently place such characters, symbology, and other pattern configurations upon a carrier such as the glass window of an automobile or the glass of a slide used for medical or other scientific purposes; especially without inducing microscopic cracks or other unacceptable damage to the carrier. It is similarly difficult to find effective and efficient apparatuses and methods for placing conductive lines or strips on glass (such as automobile windows) for heating and defrosting purposes and/or to act as an antenna to facilitate reception of

radio, telephone and other such signals and/or to shield occupants from the rays of the sun or other glare.

To facilitate further description the alphanumeric characters, bar-codes and other symbologies, stripes, strips and other pattern configurations hereinabove referred to and which are to be applied to a carrier will be referred to generically as "patterns". The term "carrier" will generically refer to the substrate, article, device or other item upon which the pattern is applied, is to be applied or has been applied; whether such carrier is a slide, automobile window, glass container or other article of glass or other material or substance contemplated herein and whatever its size, configuration, or substance as long as such may utilize the teachings herein.

The glass industry, for example, utilizes part identification markings to relate parts to their specific configurations and historical documentation. In the past, these markings were applied using human readable alphanumeric characters. After marking, such characters have been manually read and transposed from the product to the users' tracking systems. Such operations are not only labor intensive but may often result in an unacceptable number of input errors. With the advent of bar codes, many glass manufacturers began to apply bar code labels to their glass products to automate their data tracking systems. The basic structure of bar codes has limited their use to labels and packaging, which, in turn, has limited their application to logistics tracking operations. Attempts to apply bar codes and other symbology directly to products, such as glass, using permanent marking methods have met with little success due to reading difficulties and/or the inability of the markings to survive the harsh manufacturing processes used in the glass industry. These manufacturing processes include high temperatures used to temper the glass and chemical baths used to clean surfaces.

Various marking methods have been tried; and their noted weaknesses are identified as follows:

labels and tags become detached and separated from the product;

fast-drying waterproof inks applied using stencils, ink jet and hot stamp and laser transfer fade when subjected to high heat;

marking paints fade or peel from the surface;

machine engraving techniques result in material chipping that can result in the propagation of cracks;

frosted markings produced using abrasive blast, chemical and CO2 laser etching are difficult to read without use of special lighting.;and

laser bonding operations that can produce stress fractures (micro-cracks).

Chemical Vapor Deposition, (CVD), Ion Vapor Deposition (IVD), Laser-induced; Chemical Vapor Deposition (LCVD), Low Pressure Chemical Vapor Deposition (LPCVD), Physical Vapor Deposition (PVD), Pulsed Laser Deposition (PLD), Pulsed Vapor Deposition (PVD) and other similar processes have been evaluated. These processes, developed to apply thin film coatings, can be used to apply coatings to glass that are safe and will survive harsh environments. These processes, however, are not practical for use in the glass manufacturing industry because they require the use of high heat and sealed gas/vacuum chambers. They also lack the ability to direct the flow of coatings materials to form part identification markings and require the use of stencils to create such markings.

Some available literature concerning marking of carriers using the aforedescribed methods include:Cranston, John, "Vacuum Arc Vapor Deposition

Electroplating Chrome Replacement," Aerospace Environmental Technology Conference Book of Abstracts, June 1through 3, 1998, Huntsville Alabama; R.K. Singh and J. Narayan, "Pulsed-Laser Evaporation Technique for Deposition of Thin Films: Physics and Theoretical Model," Physical Review B, The American Physical Society, vol. 41, No. 13, May 1990; Thissell and H. Marcus, "Design of a Closed Loop Computer Controlled System for Selective Area Laser Deposition," Materials and Manufacturing Process, Vol. 11, 1996, pp. 673-725 and G. Riesse and R. Ebert, "Titanium Nitride Film Deposition by Laser CVD." Applied Surface Science. Vol. 106, 1996, pp. 268-274.

United States Letters Patent Number 4,847,138, patented to E. A. Boylan et al on July 11, 1989, for "Thermal Writing On Glass And-Ceramic Substrates" requires the glass composition to include a metal oxide which is exuded from the glass to form the markings; while United States Letters Patent Number 5,853,955, patented to F. Towfiq on December 29,1998 for " Substrates And Methods For Laser Marking Same" requires including with a filler component a metal component and a glass forming component to provide markings on a carrier such as electrical wire insulation. Including such metal oxides in the glass composition and such metal and glass forming components in the insulation may be otherwise unacceptable thus minimizing use thereof.

T. A. DeRossett, Jr. in United States Letters Patent Number 5,298,717, patented on March 29, 1994 for "Method And Apparatus For Laser Inscription Of An Image On A Surface" , and J. A. Richman, in United States Letters Patent Number 5,801,356, patented on September 1, 1998 for "Laser scribing On Glass Using ND:YAG Laser", on the other hand, inscribe or etch the glass carrier in order to provide markings thereon and in doing so may produce unacceptable microscopic cracks in or may otherwise damage the glass carrier.

SUMMARY OF THE INVENTION

It is therefore an object of this invention to provide new and novel apparatuses for applying patterns to carriers.

It is another object of this invention to provide new and novel methods of applying patterns to carriers.

It is yet another object of this invention to provide new and novel apparatuses and methods for applying patterns such as alphanumeric, bar-code, symbology and other markings, upon a carrier, such as glass or the like.

It is still another object of this invention to provide new and novel appparatuses and methods for applying patterns such as strips, stripes and selectively covered areas, upon a carrier, such as glass or the like.

It is yet still another object of this invention to provide new and novel apparatuses and methods for applying markings such as VIN's, and patterns such as electrically conductive paths for defrosting and defogging and for antennae, and selected area coverage for sun shading, and the like, to automobile glass.

It is a further object of this invention to provide new and novel apparatuses and methods for applying patterns to glass carriers such as slides to be utilized for medical, technical, microscope or similar purposes.

It is a further object of this invention to provide new and novel apparatuses and methods for applying patterns to the surfaces of materials which are transparent to selected laser wavelengths.

It is a further object of this invention to provide new and novel apparatuses and methods to automatically apply machine-readable part identification symbol markings to transparent materials using new laser-induced vapor deposition processes. Said

symbol markings to be captured and decoded using a reader fitted with a light detector like a charged-coupled device (CCD) or complementary metal-oxide semi-conductor (CMOS) or other technologies such as capacitance, thermal, etc..

It is still a further object of this invention to provide new and novel apparatuses and methods allowing marking processes to be carried out in an open environment and under normal atmospheric pressure and room temperature and which thus eliminate the need for heated, sealed gas/vacuum chambers, and the like.

It is yet still a further object of this invention to provide new and novel apparatuses and methods which enable the application of identification markings to transparent products like glass without the need to generate a marking mask, or the like, to do so.

It is a further object of this invention to provide new and novel apparatuses and methods to apply a relatively thin film coating of contrasting color to a surface, such coating to be subsequently selectively removed to form a representation of a part identification marking symbol, or text, or other pattern.

It is a further object of this invention to provide new and novel apparatuses and methods to apply a relatively thin film coating to a carrier, such coating exhibiting a difference in density, reflectivity, absorption, or other variance to facilitate the capture and decoding of a part identification marking applied thereto by using an image sensing reader including, but not limited to, capacitance, magneto-optic, micro-power impulse radar, thermal (IR), x-ray, and ultrasound.

It is a further object of this invention to provide new and novel apparatuses and methods to apply to a carrier a symbol which exhibits a difference in density, reflectivity, absorption, or other variance and which may optionally be covered with a coating to

hide such symbol from human view for aesthetic or security reasons while permitting the symbol to be captured with a sensing reader to decode and yield human-readable information.

It is yet still a further object of this invention to provide new and novel apparatuses and methods for applying materials to transparent products to create defrosting strips, sun shading, antennas, and circuitry.

Other objects, feature, and advantages, of the invention, in its details of construction, arrangement of parts and methods of operation, will be seen from the above and from the following detailed descriptions of the preferred embodiments when considered in conjunction with the accompanying drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWING

In the drawing:

FIG. 1 illustrates the basic elements of a conventional matrix symbol;

FIG. 2 illustrates the elements of a completed Data Matrix symbol;

FIG. 3 is a detailed view of the part/carrier configuration used to produce markings using the present invention;

FIG. 4 illustrates an apparatus to bring the product and marking provider into position for marking;

FIG. 5 illustrates another apparatus designed to bring product and marking provider into contact for marking;

FIG. 6 illustrates yet another apparatus to place a media containing provider into contact with the part substrate to facilitate marking;

FIG. 7 illustrates a method to improve contrast in markings applied to materials other than glass or similar transparent materials;

FIG. 8 illustrates an alternate marking method involving the removal of portions of a coating to produce a symbol marking;

FIG. 9 details the technique used to mark a laser-induced vapor deposition (LIVD) coated glass substrate.

FIG. 10 illustrates examples of some of the various marking applications supported by the current invention; and

FIG.11 is a schematic illustration of a carrier in the configuration of a slide, incorporating the instant invention, fabricated from a material such as plastic or glass but one which is transparent to laser wavelengths contemplated herein, and upon which a pattern has been applied employing the process of the instant invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The descriptions to follow disclose laser-induced vapor deposition (LIVD) apparatuses and methods to apply graphical representations, human-readable characters, a wide range of different machine-readable symbols, strips, stripes, conductive paths, area coverage and other selected patterns to carriers which are transparent to the wavelengths of the lasers selected for such uses.

The machine readable symbol used as an example herein is a matrix-type symbol. The matrix symbol was developed to overcome many of the deficiencies inherent to the first generation (linear bar codes) and second generation (stacked bar codes) symbol formats. One of the primary changes is the use of data cells as a symbol

of data in lieu of the strips of variable widths used in linear and stacked bar codes. The use of a data element of known size and shape makes the matrix code more versatile.

In the matrix code format (FIG 1.), black data cells 20 represent a binary "1" and white data cells 22 represent a binary "0". The basic elements of a matrix symbol are illustrated in FIG.1. Although shown as a square, matrix symbols may also be rectangular. When these binary values are used together in specific sequences, as illustrated in FIG.2, they represent alphanumeric characters. Equal-sized data cells provide for an easier decoding logic decision process than for bar codes. By knowing the size and shape of a symbol and its individual data cells, decoding software can quickly reconstruct damaged portions of the code. Matrix symbols can be scaled in size to fit into an available marking area.

Matrix codes designed to be applied to any of a variety of articles and products are known and are described in detail, for example, in U. S. Pat. No. 4,939,354 (issued Jul. 3, 1990 to D. G. Priddy, et al.). A matrix code can store from one to 2335 alphanumeric characters in any language. An encoding scheme for use with such a symbol has a high degree of redundancy that permits most marking defects to be overcome. 16-bit cyclic redundancy check and data reconstruction capabilities are included in one version; and Reed-Solomon error correction is included in another. Up to 16 symbols can be concatenated. Error checking and correction (ECC) code 200 is preferred.

FIG. 2 illustrates an example of a Data Matrix symbol 30 which has been placed in the public domain and has been recommended by the American National Standards Institute (ANSI) for use in direct part marking.

FIG. 3 depicts a transparent article or carrier 50, in the form of a glass plate, placed in contact with a marking material or media 52, which has been coated upon a marking media substrate or base 54, and which is utilized, in conjunction with a laser 58, to apply a mark 60 upon carrier plate 50 upon reaction to a laser beam 62 as will be hereinafter described in greater detail. Marking material or media 52 may be otherwise applied to, or carried by, base or substrate 54; the two together forming a convenient media provider 64 for presenting and positioning the pattern marking substance 52 with respect to the intended carrier 50. Any suitable surface may be provided to facilitate positioning of carrier 50 with respect to laser 58; and marking media provider 64 with respect to carrier 50 and so that marking media 52 is in contact with a surface 65 of carrier 50.

The process utilizes a conventionally available heat producing laser (shown schematically at 58 in FIG. 3) such as a Neodymium:Yttrium Aluminum Garnet (Nd:YAG), or Diode Pumped Neodymium-doped Yttrium Vanadate (Nd:YVO4), or other similar laser that is focused on the surface of a marking provider 64 placed in direct contact with a carrier 50 that is transparent to the wavelength of the laser selected for use. Laser 58 may be hand held or fixedly positioned with respect to carrier 50.

The operating program for the selected laser is updated to include the appropriate marking parameters required to vaporize the specific marking media 52, of marking media provider 64, or any selected other optional marking media 52 being used. These parameters include marking speed, frequency (beam pulse), and output power. The laser-marking program is initiated on command by a suitable and conventional operation initiation device, mechanism or program (not shown). Laser beam 62 passes through a near (i. e. nearest to the laser), or first surface 63, of

transparent carrier 50 and then passes through far (i. e. furthest from the laser), or second surface 65, of carrier 50 to impinge upon marking media 52. The coaction between laser beam 62 and marking media 52 generates a predetermined heat build-up. When the heat reaches the appropriate selected temperature level, marking media 52 breaks down into a gaseous vapor 66 containing molten droplets 68 of marking material.

Vapor 66 and droplets 68, are however, trapped between two surfaces (i.e. substrate or base 54 and the second, or marking, surface 65 of carrier 50), and condenses on the cooler marking surface 65 to form a hard uniform coating upon surface 65 which thereafter constitutes mark 60. The thickness of the thin film coating for mark 60 is controlled by adjusting the marking speed, frequency, aperture and power output of laser 58. Media provider marking materials 52 can be varied to provide contrast for optical reading. Material formulations can also be used to support reading using advanced sensing readers designed to detect differences in material density, temperature, capacitance, magnetism or other properties.

If an optional marking media layer is added to media provider 64, such as a film of pure metal applied to a carrier tape, care must be taken to ensure that the vaporization process is confined to the media layer to prevent contamination of the vapor with materials contained in the underlying tape, substrate or base 54.

Marking materials, for media 52, that can be used to support the present invention include, but are not to be limited to, pure metals such as aluminum, chromium, gold, lead, molybdenum, nickel, silver, tin, titanium and tungsten. A wide range of different metal alloys or compounds can also be used to support the process.

Very high quality Data Matrix™ symbols, such as symbol 30 (FIG. 2) have been successfully applied to glass, plexiglass, and plastics materials in the laboratory using a Rofin Sinar Powerline 90 Watt Nd:YAG laser configured for Transverse Electromagnetic Mode (TEM_{00}) operations (160mm lenses and 1.2mm aperture) using 0.016-inch thick metal plates obtained from Damon Company of Salem, Inc. The markings applied contained ten characters of alphanumeric information that were encoded using Error Checking and Correction (ECC) level 200. The 12x12 matrix symbols were created with a laser beam measuring 0.08mm in width. Ten lines were made to create each data cell with overlapping beam passes. The 8.04mm square symbols contained individual data cells measuring 0.67mm per side. The markings were successfully made using aluminum, brass, copper, and stainless steel plates. Excellent results were also obtained using tin-plate, galvanized plate, and anodized aluminum plates. Tests were also successfully made using 0.076mm thick metal foils obtained from Computype in Minnesota.

The laser settings used in this process were adjusted to obtain optimum results for each provider marking material. Using the laser configuration described above, the following marking parameters were established:

Marking Settings			
Provider Marking Material	Laser Marking Parameters		
	Speed (mm/s)	Power (amps)	Frequency (Hk)
Aluminum	20	16	5000
Black Anodized AL	50	18	5000
Brass	20	17	5000
Copper	20	19	5000
Galvanized Steel	20	15.5	5000
Stainless Steel	50	16	5000
Tin Plate	20	15	5000

FIG. 4 illustrates an automated approach for marking a surface 100 of an article or carrier 102 with a marking media 104 applied to a base or substrate 106 of a flexible marking media provider 108 to facilitate marking using the instant invention. Base or substrate 106 of flexible provider 108 can be constructed of metal foil, composite ribbon consisting of a metallic layer applied to a polyester film, or other suitable marking media and provider material. Other provider base materials could include paper, cloth and woven or non-woven fabrics or natural synthetic fibers. Flexible provider 108 would ideally be supplied on a spool 120 and threaded under tension rollers 130, over a backing plate 140 and to a take-up spool 150. Transparent carrier plate 102 is passed over the media 104 of media provider 108 and under a laser 160 for marking. The process illustrated in FIG 4. is preferably automated by conventional mechanisms and controls and is driven by a controller that synchronizes the operation of the laser

marker, transparent carrier handling mechanism and supply and take- up spools. The process accomplishes marking of carriers 102 as described hereinabove for carriers 50 and utilizes marking media as hereinabove described for the embodiment of FIG. 3. Laser 160, carrier 102, backing plate 140, spool 120, rollers 130 and take-up spool 150 are suitably supported and positioned for coaction as described.

FIG. 5 illustrates another automated apparatus, incorporating the instant invention, that can be used to supply and accurately position marking media providers 200. in the form of discrete plates, under a transparent carrier conveyor 202. Marking media provider plates 200 are reusable, are cut to a desired size and configuration, and each have at least a first surface 204 that carries a marking media 206. Plates 200 are stacked in a gravity fed provider dispenser 210 so that first surface 204 of each provider 200 faces up. Provider plates 200 are successively fed from dispenser 210 by conventional mechanism (not shown) that feeds media providers 200 onto a provider conveyor 220 with their respective marking media 206 facing upwardly and which passes sucessive provider plates 200 under carrier conveyor 202. Carriers 230, to be marked, on the other hand, are conveyed by conveyor 202 so as to pass over conveyor 220. A marking station 240 is provided where conveyors 202 and 220 intersect. A laser 250, mounted at marking station 240, over the intersection of carrier conveyor 202 and media provider conveyor 220, is directed and controlled to perform a marking operation when marking media 206 carried by first surface 204 of a media provider plate 200 and a marking surface 252 of a carrier 230, to be marked, are properly positioned in juxtaposition to each other. The used/reusable media providers 200 may thereafter be conveyed and routed into a hopper 260 for reuse. During a second, or reuse pass, media providers 200 can be inverted to expose a second or underside surface 262

thereof to laser 250; providing that such underside surfaces 262 have each been provided with an appropriate marking media 264. Adjustments can also be made to the feed from provider dispenser 210 to position unused portions of either surface 206 or 262 of a provider 200 to laser marker 250 and a carrier 230 to be marked. This described process may be fully automated to accommodate high volume manufacturing operations. It should be understood that media for marking of providers 200 and laser 250 are similar to those described above for the embodiments of FIGS. 3 and 4. Laser 250, conveyors 202 and 220, dispenser 210 and hopper 260 are of conventional construction and are supported and positioned for coaction with each other, and coact with each other, by suitable and conventionally available supports and mechanisms and controls.

FIG. 6 illustrates yet another automated apparatus, incorporating the instant invention, that can be used to apply marking media coated labels 310, like those defined in U.S. Patent Number 5,801,356, to the underside 312 of a transparent carrier 320 to be marked. In this embodiment, pre-printed labels 310 are fed to a mechanical applicator 330 via a supply reel 340. The label substrate or backing tape 342 is thereafter taken up on a take-up reel 350. A base blade 352 at the end of applicator 330 presses label 310 firmly against the surface of carrier to seal label 310 onto carrier 312 for subsequent laser marking operations to be carried out as a next step or at a later time but as described hereinabove with reference to the embodiment of FIGS. 3-5. After the marking operation label 310 is removed via mechanical means (by scraping or blowing off) or destroyed using high heat, acid or other desolving agent.

In addition to transparent product marking, the process of the instant invention may improve the contrast level of markings applied to both metallic and non-metallic

materials as shown on FIG 7. The improvement in marking contrast is brought about when gaseous residue 410, which may otherwise have been ejected from the marking provider (as shown at A), is trapped between the transparent carrier 420 and substrate 430 and confined within the marking area 440 (as shown at B). The direction of laser is shown by arrow X. Improvements in marking contrast are thus obtained using less power than would normally be applied to a surface to make a mark. This reduction in marking output power results in a marked decrease in surface disruption, which is an important concern for makers of components used in safety critical applications.

Another alternate embodiment of apparatus, which incorporates the instant invention, involves the application of an LIVD patch 450 to a surface 452 of a glass carrier 454 to form a marking surface 456 as illustrated in FIG 8. In this approach, a coating 460 is applied to transparent plate or carrier 454 to form patch 450 that can be subsequently marked as shown, for example at 462 using the same laser and settings as hereinabove described for the previously described embodiments. This process may be otherwise accomplished as set forth hereinafter with respect to FIG. 9.

A transparent carrier 510, with an LIVD coating 512, is positioned atop mounting blocks 520 so as to form an open space 530 between a bottom, or marking surface, 532 of transparent carrier 510 and a work piece 540. A laser beam 550 may be projected through transparent carrier plate 510 to strike the LIVD coating 512 to produce heat. As the temperature rises, LIVD coating 512 is vaporized at selected locations and ejected, as shown at 570, downward from transparent carrier plate 510, forming a representation or representations of a part identification symbol 580 on marking surface 532 of carrier 510. A gap of over ½-inch is maintained between transparent plate carrier 510 and workpiece 540 to ensure that laser beam 550 is out of focus when it strikes

work-piece 540 to preclude damage to its surface. Markings 580 produced using this technique or process may be more desirable in some applications because the LIVD coating 512 reduces the amount of glare emanating from the surface of carrier 510 thereby making it is easier to capture and decode with an optical reader.

FIG. 10 schematically illustrates a typical application of the apparatuses and methods described hereinabove as such might be applied to applying identification markings and selected area coverage to the glass windows for an airplane, automobile or other on or off road vehicle. In this example an airplane 800 includes a windshield or windscreen 802 and a pilots side window 804 as well as a rear seat passenger window 806. Airplane 800 may also be provided with windows for the front and rear seat passanger sides as well as a rear window. A machine readable identification symbol or number (VIN) -alphanumeric or otherwise, has been applied to windshield 802 at 830; while a defrosting strip 832, of conductive material, has been applied to windshield 802 and is otherwise connected to circuitry and controls to effect defrosting of windshield 802. Selected strips or stripes 836, also of electrically conductive material, have been applied to pilot"s window 804 and are electrically connected in suitable circuits to provide an antenna for radio and/or telephone reception. In addition, an upper area of pilots side window 804 has been covered by a sun shading application 840 comprising a plurality of dot-like markings in a predetermined array. The herein described markings, strips, stripes and selected area coverages, have been applied by apparatuses as hereinabove described and utilizing processes as hereinabove described.

FIG.11 schematically shows a carrier 900, in the configuration of a slide, with a marking strip 902 applied thereto and which is to have identification indicia or symbology applied thereto. Such identification indicia or symbology and strip 902 are

applied to slide 900 by apparatuses and methods such as those described hereinabove. Slide 900 is fabricated from plexiglass but plastic, glass or other materials, suitable for use as a laboratory slide, or a slide for other research purposes, and which are transparent to the wavelength of the laser to be utilized to apply and mark strip 902 may also be used for carrier 900. Marking strip 902 has been applied, or coated upon carrier 900, by apparatuses and methods as hereinabove described.

The laser devices for the apparatuses described hereinabove may be fixedly mounted, hand held, or otherwise positioned, to coact with the marking media to mark the carrier parts to be marked. For example, the pattern markings applied (coated) upon windows (as for the schematic airplane of FIG. 10) may be applied to the various windows before the windows are installed in the airplane, automobile or other vehicle. Alternatively the patterns (markings) may be applied to the windows after the airplane, automobile or other vehicle is fully assembled and either prior to its first use or after it has, in fact, been flown, driven or otherwise utilized. To do so one need only position an appropriate laser (with controls) to one side of the window (the side not to be patterned) and a media provider (with appropriate media material) to the other side of the window and up against the window surface. The media provider can be positioned with its media material against the window at the place to be marked by any suitable device or devices. Once the laser beam has been directed through the window and upon the marking media the marking process can proceed as described above for the hereinabove described embodiments.

While the articles or carriers to be marked, as described hereinabove, have been shown and described as glass plates and windows and as plexiglass or plastic slides it should be understood that any carrier may be marked according to the instant invention

as long as the carrier is transparent to the wavelength of the heat beam producing device which has been described herein as a heat producing laser. For example colored glass, uncut and cut natural and synthetic gemstones, boules from which synthetic materials and laser rods are fabricated and the laser rods themselves are just further examples of articles or carriers that may be marked with a pattern according to the instant invention. The patterns to be marked upon such carriers may constitute not only those described hereinabove but may include any configuration of pattern desired and such patterns may be so applied in any selected size including ones that are microscopic in dimension. Furthermore patterns applied to a carrier, as hereinabove described, may be removed from the carrier by vaporization with a heat producing device such as the lasers utilized herein; while marks that are etched or otherwise applied may not be so readily removed.

From the above description it will thus be seen that there has been described new and novel apparatuses and methods for applying numeric, alphanumeric, or other symbology to a transparent part and furthermore for applying strips, stripes and coverage of selected areas for such parts.

Numerous alterations of the structure herein disclosed will suggest themselves to those skilled in the art. However, it is to be understood that the present disclosure relates to the preferred embodiments of the invention, which is for purposes of illustration only, and not to be construed as a limitation of the invention. All modifications, which do not depart from the spirit of the invention, are intended to be included within the scope of the appended claims.

WHAT IS CLAIMED IS:

1. Apparatus for applying a pattern to a carrier, comprising:

(a) a heat producing laser;

(b) a support for positioning said laser to project its beam towards and through a carrier when positioned in the path of the laser beam; and

(c) a marking media provider holder disposed to position the marking media of a marking media provider against a predetermined surface of a carrier when positioned in the path of a laser beam;

(d) the laser beam, after passing through said carrier, focusing upon a surface of said marking media to vaporize same such that the vaporized marking media condenses upon the predetermined surface to apply a pattern thereto.

2. The apparatus of claim 1 wherein the pattern to be applied to the carrier is to include alphanumeric characters.

3. The apparatus of claim 1 wherein the pattern to be applied to a carrier is to include information recorded in a bar-code configuration.

4. The apparatus of claim 1 wherein the pattern to be applied to a carrier is to include information recorded in a two-dimensional symbology.

5. The apparatus of claim 1 wherein the pattern to be applied to a carrier includes at least one strip of a metal.

6. The apparatus of claim 1 wherein the pattern to be applied to a carrier includes at least one electrically conductive strip.

7. The apparatus of claim 1 wherein the pattern to be applied includes a plurality of electrically conductive strips that are electrically interconnected.

8. The apparatus of claim 1 wherein the pattern to be applied to the carrier includesa predetermined array of markings positioned to facilitate shading from the sun.

9. The apparatus of claim 1 wherein the carrier to which a pattern is to be applied is fabricated from a predetermined material which is transparent to the wavelengths emitted by the laser.

10. The apparatus of claim 9 wherein the carrier to which a pattern is to be applied is fabricated from materials including glass, plexiglass or plastic or combinations thereof.

11. The apparatus of claim 9 wherein the carrier to which a pattern is to be applied is a window.

12. The apparatus of claim 9 wherein the carrier to which a pattern is to be applied is a slide to be utilized for medical, technical or other microscope investigations.

13. The apparatus of claim 9 wherein the carrier to which a pattern is to be applied is a gemstone.

14. The apparatus of claim 9 wherein the material to which a pattern is to be applied is a material from which laser rods are fabricated.

15. The apparatus of claim 1 wherein said heat producing laser is a Neodymium:Yttrium Aluminum Garnet (ND:YAG) laser.

16. The apparatus of claim 1 wherein said heat producing laser is a Diode Pumped Neodymium-doped Yttrium Vanadate (ND:YVO4) laser.

17. The apparatus of claim 1 wherein the marking media may be a metal such as aluminum, chromium, gold, lead, molybdenum, nickel,silver, tin, titanium or tungston.

18. The apparatus of claim 1 wherein the marking medai may be an alloy of metal.

19. A marking device for coating a mark upon an article to facilitate identification of the article or of something associated with the article or to otherwise enhance use of the article or of that which is associated with the article, comprising:

(a) heat producing means for generating a heat producing beam;

(b) support means for positioning an article to be marked in the path of said heat producing beam;

(c) marking means for applying a coating in a predetermined pattern upon a face of an article;

(d) marking means holding means for positioning said marking means against a face of an article when the article is positioned by said support means;

(e) said heat producing beam being positioned and controlled to pass through the article, when the article is positioned by said support means, to impinge upon a marking means, when the marking means is positioned by said marking means holding means, to vaporize at least a part of the marking means;

(f) said vaporized marking means condensing upon and coating the article to apply a mark thereto.

20. The marking device of claim 19 wherein the mark to be coated upon an article is to include alphanumeric characters.

21. The marking device of claim 19 wherein the mark to be coated upon an article is to include information recorded in a bar-code configuration.

22. The marking device of claim 19 wherein the mark to be coated upon an article is to include information recorded in a two-dimensional symbology.

23. The marking device of claim 19 wherein the mark to coated upon an article includes at least one strip of a metal.

24. The marking device of claim 19 wherein the mark to be coated upon an article includes at least one electrically conductive strip.

25. The marking device of claim 19 wherein the mark to be coated upon an article includes a plurality of electrically conductive strips that are electrically interconnected.

26. The marking device of claim 19 wherein the mark to be coated upon an article includes a predetermined array of markings positioned to facilitate shading from the sun.

27. The marking device of claim 19 wherein the article upon which a mark is to be coated is fabricated from a predetermined material which is transparent to the wavelengths emitted by the laser.

28. The marking device of claim 27 wherein the article upon which a mark is to be coated is fabricated from materials including glass, plexiglass or plastic or combinations thereof.

29. The marking device of claim 27 wherein the article upon which a mark is to be coated is a window.

30. The marking device of claim 27 wherein the article upon which a mark is to be coated is a slide utilized for medical, technical or other microscope investigations.

31. The marking device of claim 27 wherein the article upon which a mark is to be coated is a gemstone.

32. The marking device of claim 27 wherein the article upon which a mark is to be coated is the material from which laser rods are fabricated.

33. The marking device of claim 19 wherein said heat producing means is a Neodymium:Yttrium Aluminum Garnet (ND:YAG) laser.

34. The marking device of claim 19 wherein said heat producing means is a Diode Pumped Neodymium-doped Yttrium Vanadate (ND:YVO4) laser.

35. The marking device of claim 19 wherein said marking means may be a metal such as aluminum, chromium, gold, lead, molybdenum, nickel, silver, tin, titanium, or tungston.

36. The marking device of claim 19 wherein said marking means may be an alloy of metal.

37. The method of applying a pattern to a carrier comprising:

(a) projecting a beam of energy along a predetermined path;

(b) positioning a carrier upon which a pattern is to be applied in said predetermined path and so that the beam of energy passes through the carrier;

(c) positioning a marking media against said carrier and so as to be focused upon by said beam of energy as it exits the carrier; and

(d) controlling said beam of energy to produce heat to vaporize said marking media;

(e) said positioning of said marking media against the carrier surface inducing said vaporized marking media to condense indellibly upon the carrier surface in the configuration of said predetermined pattern,

38. The method of claim 37 including configuring the pattern to include alpha-numeric characters.

39. The method of claim 37 including configuring the pattern to include information recorded in a bar-code configuration.

40. The method of claim 37 including configuring the pattern to include information recorded in a two-dimensional symbology.

41. The method of claim 37 including configuring the pattern to include at least one strip of a metal.

42. The method of claim 37 including configuring the pattern to include at least one electrically conductive strip.

43. The method of claim 37 including configuring the pattern to include a plurality of electrically conductive strips that are electrically interconnected.

44. The method of claim 37 including configuring the pattern to include a predetermined array of markings positioned to facilitate shading from the sun.

45. The method of claim 37 including utilizing a carrier fabricated from a predetermined material which is transparent to the wavelengths emitted by the laser.

46. The method of claim 45 including utilizing a carrier fabricated from materials including glass, plexiglass or plastic or combinations thereof.

47. The method of claim 45 wherein the carrier to which a pattern is to be applied is a window.

48. The method of claim 45 wherein the carrier to which a pattern is to be applied is a slide to be utilized for medical, technical or other microscope investigations.

49. The method of claim 45 wherein the carrier to which a pattern is to be applied is a gemstone.

50. The method of claim 45 wherein the material to which a pattern is to be applied is a material from which laser rods are fabricated.

51. The method of claim 37 including utilizing a laser to generate said beam of energy.

52. The method of claim 51 including utilizing a Neodymium:Yttrium Aluminum Garnet (ND:YAG) laser to generate said beam of energy.

53. The method of claim 51 including utilizing a Diode Pumped Neodymium-doped Yttrium Vanadate (ND:YVO4) laser to generate said beam of energy.

54. The method of claim 37 including utilizing a metal such as aluminum, chromium, gold, lead, molybdenum, nickel,silver, tin, titanium or tungston as said marking media.

55. The method of claim 37 including utilizing an alloy of metal.as said marking media.

57. An apparatus for applying a coating to a hard, amporphous, transparent substances made by fusing together one or more of the oxides (silicon, magnesium, calcium, or potassium) that are cooled rapidly to prevent crystallization or transparent mouldable polymeric substances in a prescribed pattern using laser-induced vapor deposition technology.

58. A method for applying a coating to a hard, amporphous, transparent substances made by fusing together one or more of the oxides (silicon, magnesium, calcium, or potassium) that are cooled rapidly to prevent crystallization or transparent mouldable polymeric substances in a prescribed pattern using laser-induced vapor deposition technology.

59. The method of claim 58, wherein a laser is used to vaporize material that condenses on a transparent substrate placed in direct contact with the carrier.

60. The method of claim 58 wherein a thin film coating of contrasting color is applied to a surface that is subsequently selectively removed to form a representation of a part identification markingand wherein said marking is captured and decoded using an optical reader fitted with a light detector like a charged-coupled device (CCD) or complementary metal-oxide semi-conductor (CMOS).

61. The method of claim 58, wherein a thin film coating is applied to a substrate that exhibits a different density, reflectivity, absorption or other variance to promote the capture and decoding of a part identification marking using a capacitance, magneto-optic, micro-power impulse radar, thermal (IR), x-ray, ultrasound or other similar sensing apparatus.

62. The method of claim 58, including positioning a flexible marking media carrier such as a coated ribbon under a transparent substrate in an automated manner to facilitate marking.

63. The method of claim 58 including improving marking contrast on metallic substrates by using lower laser output powerto thus reduce surface disruption.

AMENDED CLAIMS
[received by the International Bureau on 15 January 2001 (15.01.01);
original claim 1 amended; remaining claims unchanged (1 page)]

1. Apparatus for applying a pattern, formed from a marking media, upon a predetermined surface of a carrier, comprising:

(a) a heat producing laser for providing a laser beam directed along a selected laser path;

(b) a media holder disposed to position the marking media in proximity to the predetermined surface of the carrier and within the laser beam path;

(c) a support for positioning said laser to direct its laser beam along said laser beam path towards and through a carrier, when positioned in the path of the laser beam, and upon the marking media, when disposed in proximity to the predetermined surface of the carrier, to vaporize the marking media in a selected manner such that the vaporized marking media condenses upon the predetermined surface of the carrier to apply a pattern thereupon.

2. The apparatus of claim 1 wherein the pattern to be applied to the carrier is to include alphanumeric characters

3. The apparatus of claim 1 wherein the pattern to be applied to a carrier is to include information recorded in a bar-code configuration.

4. The apparatus of claim 1 wherein the pattern to be applied to a carrier is to include information recorded in a two-dimensional symbology.

5. The apparatus of claim 1 wherein the pattern to be applied to a carrier includes at least one strip of a metal.

6. The apparatus of claim 1 wherein the pattern to be applied to a carrier includes at least one electrically conductive strip.

7. The apparatus of claim 1 wherein the pattern to be applied includes a plurality of electrically conductive strips that are electrically interconnected.

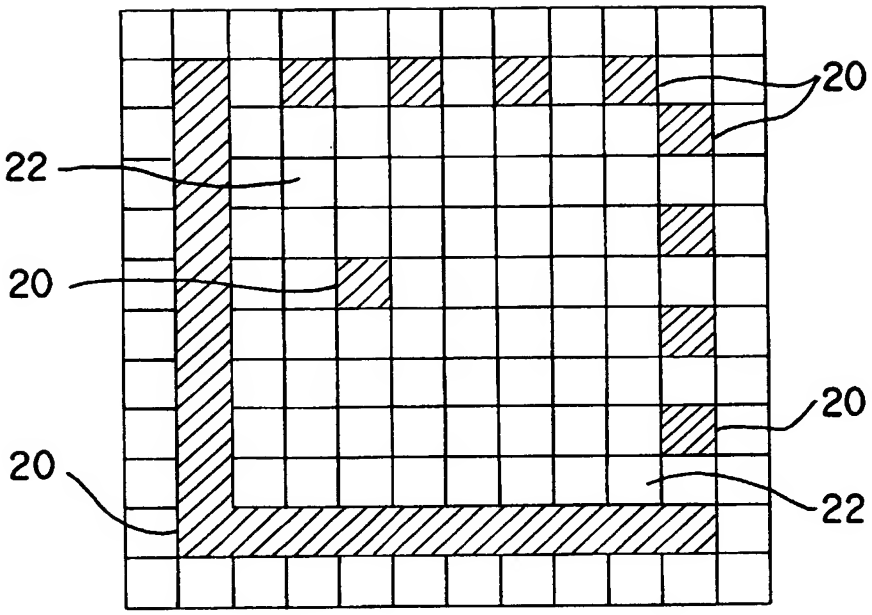

FIG. 1 (PRIOR ART)

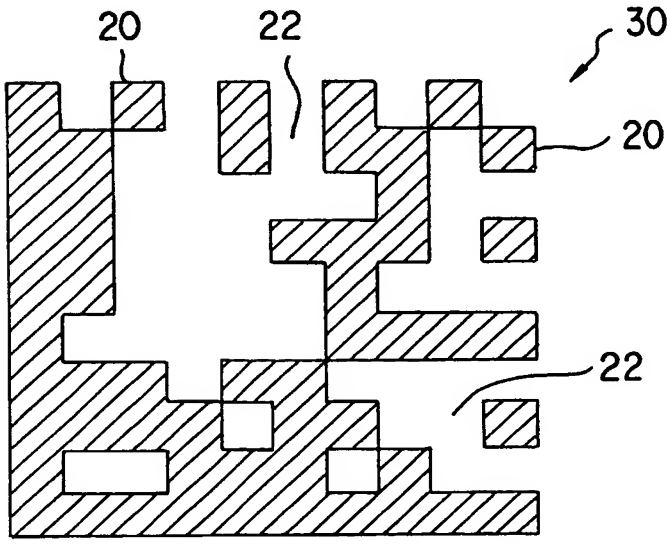

FIG. 2 (PRIOR ART)

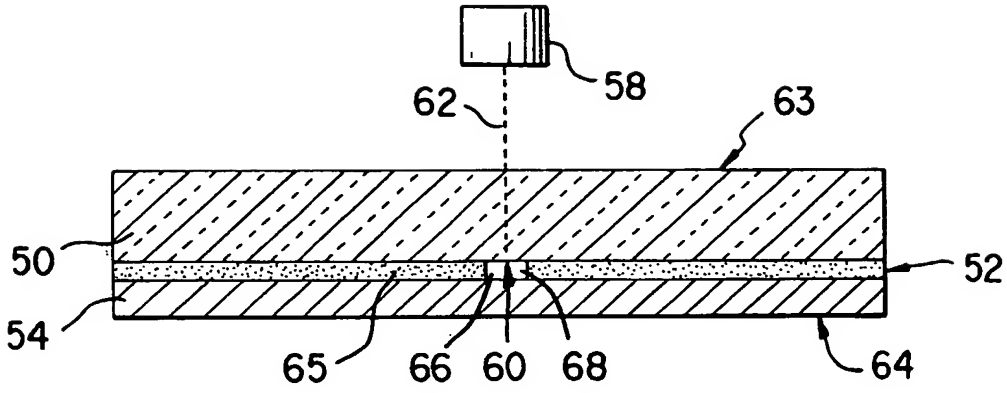
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FIG. 3

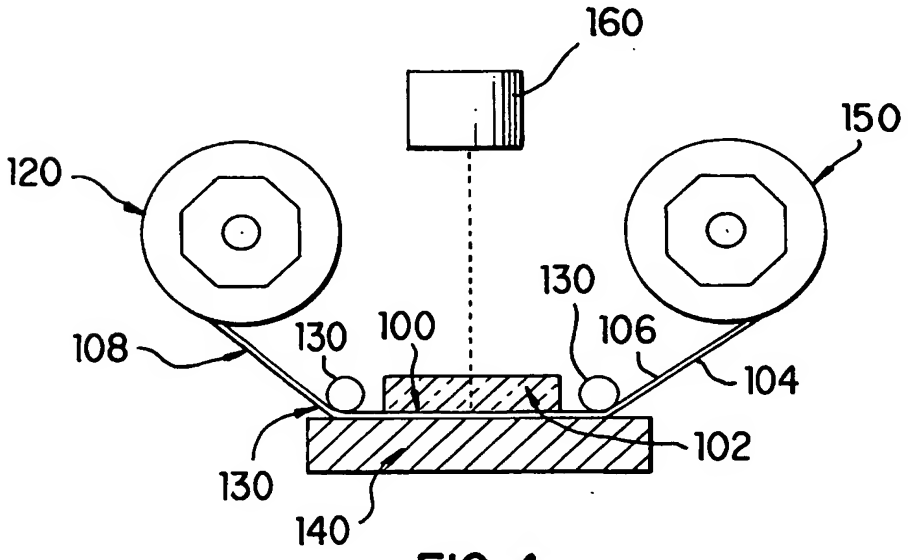
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FIG. 4

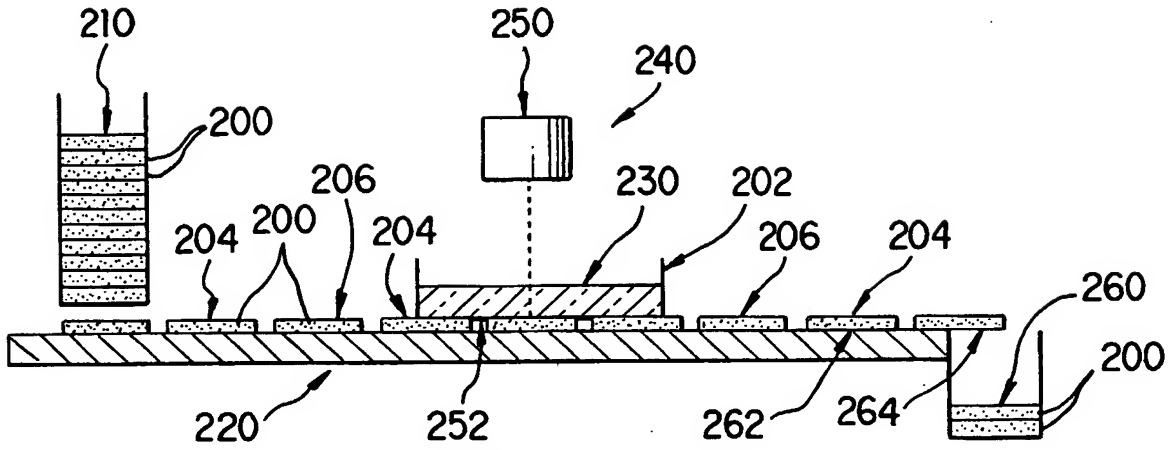
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FIG.5

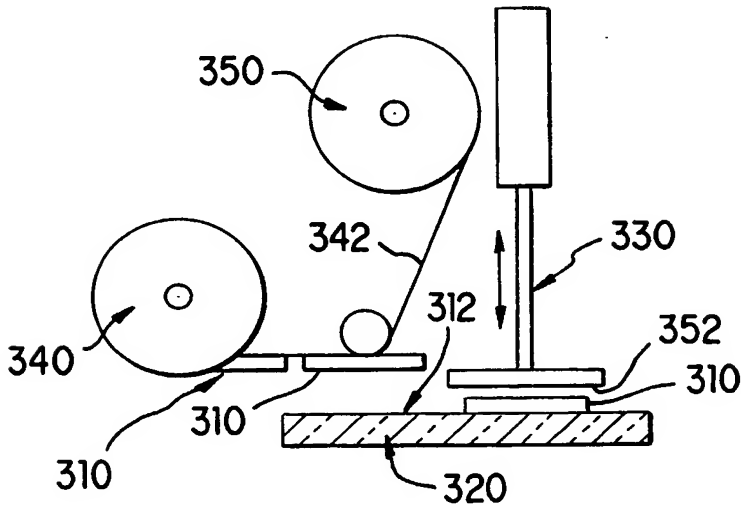
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FIG.6

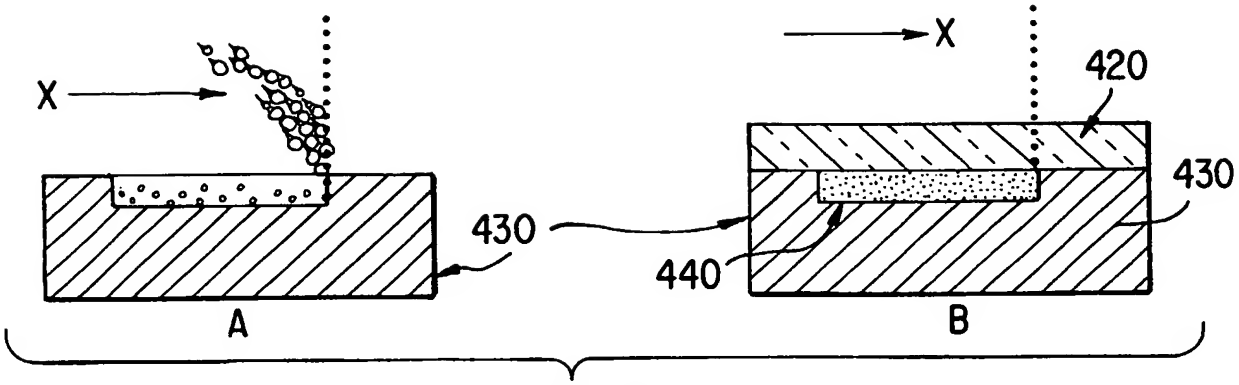

FIG. 7

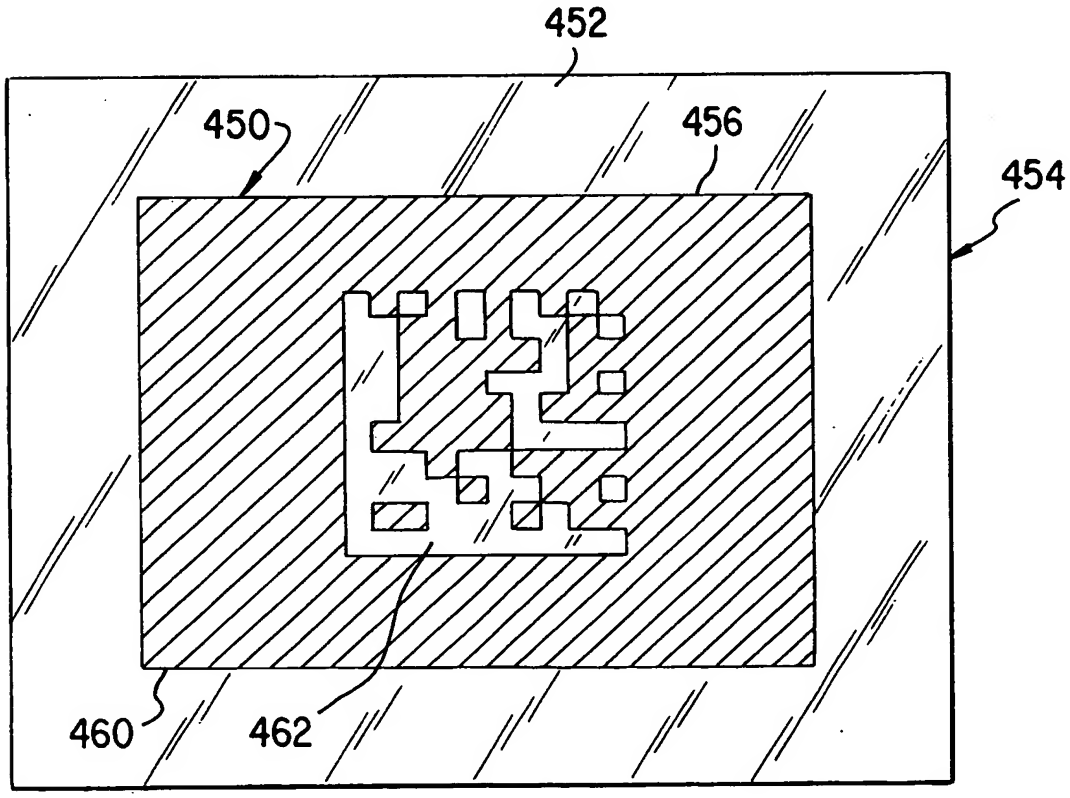

FIG. 8

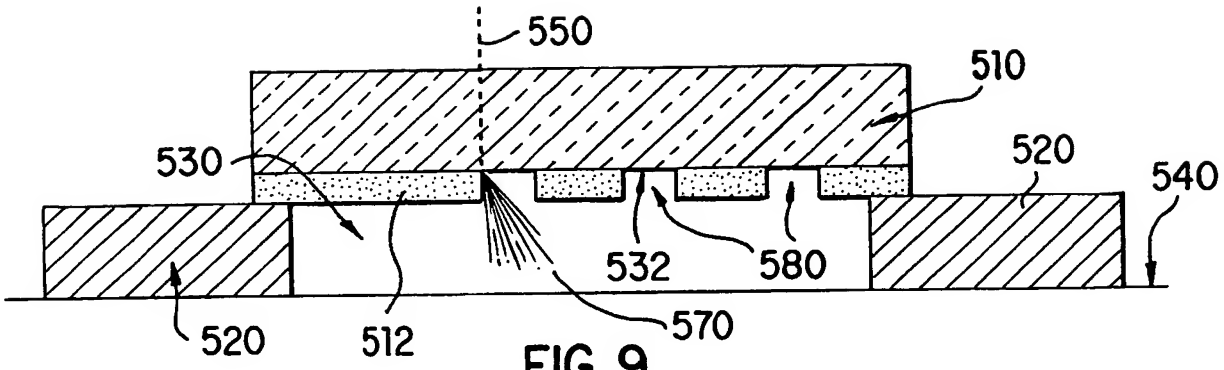

FIG. 9

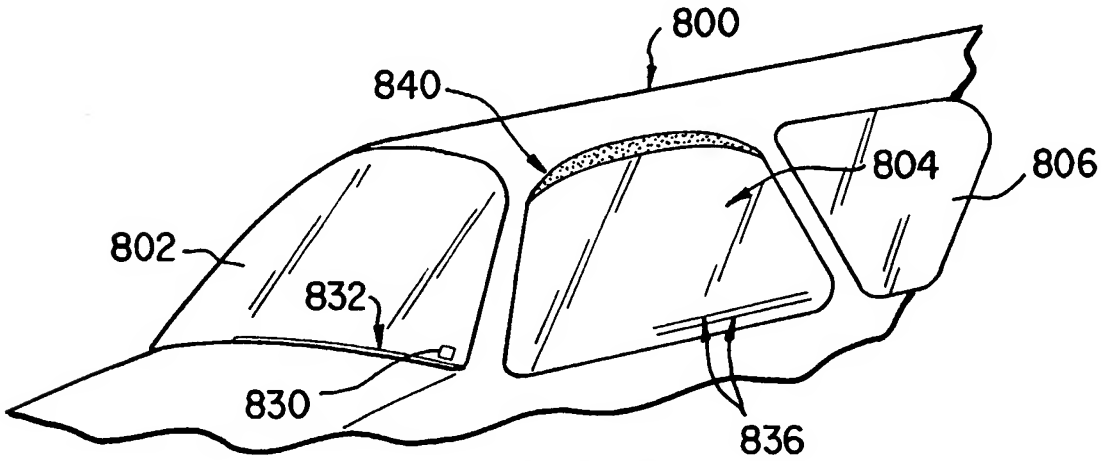

FIG. 10

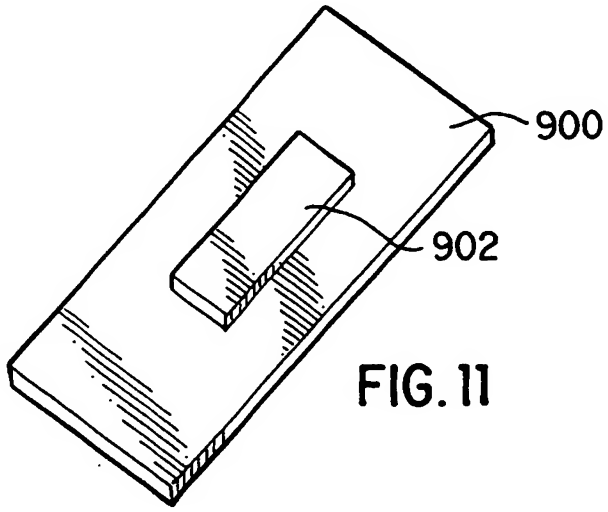

FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/17862

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :B23K 26/02
US CL :216/65, 94; 118/722

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 216/65, 94; 118/722

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

http://www.aip.org
search terms & logic: "(laser* <and> mask* <and> (vapor* <or> sublimat*) <and> pattern* <and> metal*)"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,171,650 A (ELLIS et al) 15 December 1992, column 5, lines 21-32; column 14, lines 7-21, 39-44; column 13, lines 24-26, 53-59; column 12, lines 39-45	1,3-12,15, 17,18
Y	US 5,171,650 (ELLIS et al) 15 December 1992, column 14, lines 54-64; column 15, lines 13-19	16
Y	US 5,902,688 A (ANTONIADIS et al) 11 May 1999, Figures 1a,1b; column 4, lines 25-29	2
Y	US 5,410,125 A (WINSTON et al) 25 April 1995, column 1, lines 58-68, 49-56	13

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 12 OCTOBER 2000	Date of mailing of the international search report 14 NOV 2000
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer RUDY ZERVIGON Telephone No. (703) 308-0651

Form PCT/ISA/210 (second sheet) (July 1998)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/17862

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 14
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

Claim 14 is vague and does not allow a person of ordinary skill to asertain the scope and context of the claim.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-18

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/17862

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Groups I, claims 1-18 drawn to an apparatus for applying a pattern to a carrier.

Groups II, claims 19-36 drawn to a marking device for coating a mark upon an article.

Group II, claims 37-63, drawn to a method for applying a pattern to a carrier.

The inventions listed as Groups I and III do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The technical feature for creating a pattern on a carrier does not correspond to the same technical feature for the apparatus needed to create a pattern on a carrier.

The inventions listed as Groups I and II do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The technical feature for a marking device applying a pattern to a carrier does not correspond to the same technical feature for the apparatus needed to create a pattern on the carrier.

The inventions listed as Groups II and III do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The technical feature for a marking device applying a pattern to a carrier does not correspond to the same technical feature for creating a pattern on a carrier.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
1 February 2001 (01.02.2001)

PCT

(10) International Publication Number
WO 01/07197 A1

(51) International Patent Classification[7]: B23K 26/02

(21) International Application Number: PCT/US00/17862

(22) International Filing Date: 24 July 2000 (24.07.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/359,230 22 July 1999 (22.07.1999) US

(71) Applicant: ROBOTIC VISION SYSTEMS INC. [US/US]; 5 Shawmut Road, Canton, MA 02021 (US).

(72) Inventors: ROXBY, Donald, L.; 18 Victorian Rose Lane, Gurly, AL 35748 (US). SEWELL, Carl; 465 Byron Moman Road, Albertville, AL 35950 (US).

(74) Agents: WASSON, Mitchell, B. et al.; Hoffman, Wasson & Gitler, P.C., Suite 522, 2361 Jefferson Davis Highway, Arlington, VA 22202 (US).

(81) Designated States *(national)*: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *With international search report.*
— *With amended claims.*

Date of publication of the amended claims: 22 March 2001

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 01/07197 A1

(54) Title: APPARATUSES AND METHODS FOR APPLYING AN INDELIBLE AND CONTRASTING PATTERN ONTO A CARRIER

(57) Abstract: Methods and apparatus are provided to apply permanent identification markings onto transparent carriers using laser induced vapor deposition technology. This is accomplished by vaporizing material from a marking media carried by a substrate using the heat generated from a laser and transferring the marking material onto a transparent carrier, the markings are dectectable using an optical reader or sensing device like x-ray, thermal imaging, ultrasound, magneto-optic, micro-power impulse radar, capacitance, or other similar sensing means.

AMENDED CLAIMS
[received by the International Bureau on 15 January 2001 (15.01.01);
original claim 1 amended; remaining claims unchanged (1 page)]

1. Apparatus for applying a pattern, formed from a marking media, upon a predetermined surface of a carrier, comprising:

(a) a heat producing laser for providing a laser beam directed along a selected laser path;

(b) a media holder disposed to position the marking media in proximity to the predetermined surface of the carrier and within the laser beam path;

(c) a support for positioning said laser to direct its laser beam along said laser beam path towards and through a carrier, when positioned in the path of the laser beam, and upon the marking media, when disposed in proximity to the predetermined surface of the carrier, to vaporize the marking media in a selected manner such that the vaporized marking media condenses upon the predetermined surface of the carrier to apply a pattern thereupon.

2. The apparatus of claim 1 wherein the pattern to be applied to the carrier is to include alphanumeric characters

3. The apparatus of claim 1 wherein the pattern to be applied to a carrier is to include information recorded in a bar-code configuration.

4. The apparatus of claim 1 wherein the pattern to be applied to a carrier is to include information recorded in a two-dimensional symbology.

5. The apparatus of claim 1 wherein the pattern to be applied to a carrier includes at least one strip of a metal.

6. The apparatus of claim 1 wherein the pattern to be applied to a carrier includes at least one electrically conductive strip.

7. The apparatus of claim 1 wherein the pattern to be applied includes a plurality of electrically conductive strips that are electrically interconnected.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
1 February 2001 (01.02.2001)

PCT

(10) International Publication Number
WO 01/07197 A1

(51) International Patent Classification[7]: B23K 26/02

(21) International Application Number: PCT/US00/17862

(22) International Filing Date: 24 July 2000 (24.07.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/359,230 22 July 1999 (22.07.1999) US

(71) Applicant: ROBOTIC VISION SYSTEMS INC. [US/US]; 5 Shawmut Road, Canton, MA 02021 (US).

(72) Inventors: ROXBY, Donald, L.; 18 Victorian Rose Lane, Gurly, AL 35748 (US). SEWELL, Carl; 465 Byron Moman Road, Albertville, AL 35950 (US).

(74) Agents: WASSON, Mitchell, B. et al.; Hoffman, Wasson & Gitler, P.C., Suite 522, 2361 Jefferson Davis Highway, Arlington, VA 22202 (US).

(81) Designated States *(national)*: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *With international search report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 01/07197 A1

(54) Title: APPARATUSES AND METHODS FOR APPLYING AN INDELIBLE AND CONTRASTING PATTERN ONTO A CARRIER

(57) Abstract: Methods and apparatus are provided to apply permanent identification markings onto transparent carriers using laser induced vapor deposition technology. This is accomplished by vaporizing material from a marking media carried by a substrate using the heat generated from a laser and transferring the marking material onto a transparent carrier, the markings are dectectable using an optical reader or sensing device like x-ray, thermal imaging, ultrasound, magneto-optic, micro-power impulse radar, capacitance, or other similar sensing means.

APPARATUSES AND METHODS FOR APPLYING AN INDELIBLE AND CONTRASTING PATTERN ONTO A CARRIER

BACKGROUND OF THE INVENTION- FIELD OF APPLICATION

This present invention relates to the application of marks (human readable and /or machine readable) and other pattern configurations (stripes, symbols, etc.) to a substrate or other carrier; and, more particularly, to apparatuses and methods for the permanent application of such marks and/or other pattern configurations to a carrier.

BACKGROUND OF THE INVENTION-DESCRIPTION OF THE PRIOR ART

The placing of markings, such as human or machine readable alphanumeric characters or machine readable bar-codes or other symbology upon a carrier, such as an automobile license plate, credit card or similar item, for identification purposes, is not only common place today but there are numerous apparatuses and methods for accomplishing same. Similarly apparatuses and methods may be readily found for the application of lines and/or stripes and/or other configurations on such carriers. However it is quite difficult to find an apparatus and/or method to effectively and efficiently place such characters, symbology, and other pattern configurations upon a carrier such as the glass window of an automobile or the glass of a slide used for medical or other scientific purposes; especially without inducing microscopic cracks or other unacceptable damage to the carrier. It is similarly difficult to find effective and efficient apparatuses and methods for placing conductive lines or strips on glass (such as automobile windows) for heating and defrosting

purposes and/or to act as an antenna to facilitate reception of radio, telephone and other such signals and/or to shield occupants from the rays of the sun or other glare.

To facilitate further description the alphanumeric characters, bar-codes and other symbologies, stripes, strips and other pattern configurations hereinabove referred to and which are to be applied to a carrier will be referred to generically as "patterns". The term "carrier" will generically refer to the substrate, article, device or other item upon which the pattern is applied, is to be applied or has been applied; whether such carrier is a slide, automobile window, glass container or other article of glass or other material or substance contemplated herein and whatever its size, configuration, or substance as long as such may utilize the teachings herein.

The glass industry, for example, utilizes part identification markings to relate parts to their specific configurations and historical documentation. In the past, these markings were applied using human readable alphanumeric characters. After marking, such characters have been manually read and transposed from the product to the users' tracking systems. Such operations are not only labor intensive but may often result in an unacceptable number of input errors. With the advent of bar codes, many glass manufacturers began to apply bar code labels to their glass products to automate their data tracking systems. The basic structure of bar codes has limited their use to labels and packaging, which, in turn, has limited their application to logistics tracking operations. Attempts to apply bar codes and other symbology directly to products, such as glass, using permanent marking methods have met with little success due to reading difficulties and/or the inability of the markings to survive the harsh manufacturing processes used in the glass industry. These

manufacturing processes include high temperatures used to temper the glass and chemical baths used to clean surfaces. Various marking methods have been tried; and their noted weaknesses are identified as follows:

labels and tags become detached and separated from the product;

fast-drying waterproof inks applied using stencils, ink jet and hot stamp and laser transfer fade when subjected to high heat;

marking paints fade or peel from the surface;

machine engraving techniques result in material chipping that can result in the propagation of cracks;

frosted markings produced using abrasive blast, chemical and CO2 laser etching are difficult to read without use of special lighting.;and

laser bonding operations that can produce stress fractures (micro-cracks).

Chemical Vapor Deposition, (CVD), Ion Vapor Deposition (IVD), Laser-induced; Chemical Vapor Deposition (LCVD), Low Pressure Chemical Vapor Deposition (LPCVD), Physical Vapor Deposition (PVD), Pulsed Laser Deposition (PLD), Pulsed Vapor Deposition (PVD) and other similar processes have been evaluated. These processes, developed to apply thin film coatings, can be used to apply coatings to glass that are safe and will survive harsh environments. These processes, however, are not practical for use in the glass manufacturing industry because they require the use of high heat and sealed gas/vacuum chambers. They also lack the ability to direct the flow of coatings materials to form part identification markings and require the use of stencils to create such markings.

Some available literature concerning marking of carriers using the aforedescribed methods include:Cranston, John, "Vacuum Arc Vapor Deposition Electroplating Chrome Replacement," Aerospace Environmental Technology Conference Book of Abstracts, June 1through 3, 1998, Huntsville Alabama; R.K. Singh and J. Narayan, "Pulsed-Laser Evaporation Technique for Deposition of Thin Films: Physics and Theoretical Model," Physical Review B, The American Physical Society, vol. 41, No. 13, May 1990; Thissell and H. Marcus, "Design of a Closed Loop Computer Controlled System for Selective Area Laser Deposition," Materials and Manufacturing Process, Vol. 11, 1996, pp. 673-725 and G. Riesse and R. Ebert, "Titanium Nitride Film Deposition by Laser CVD." Applied Surface Science. Vol. 106, 1996, pp. 268-274.

United States Letters Patent Number 4,847,138, patented to E. A. Boylan et al on July 11, 1989, for "Thermal Writing On Glass And-Ceramic Substrates" requires the glass composition to include a metal oxide which is exuded from the glass to form the markings; while United States Letters Patent Number 5,853,955, patented to F. Towfiq on December 29,1998 for " Substrates And Methods For Laser Marking Same" requires including with a filler component a metal component and a glass forming component to provide markings on a carrier such as electrical wire insulation. Including such metal oxides in the glass composition and such metal and glass forming components in the insulation may be otherwise unacceptable thus minimizing use thereof.

T. A. DeRossett, Jr. in United States Letters Patent Number 5,298,717, patented on March 29, 1994 for "Method And Apparatus For Laser Inscription Of An Image On A Surface" , and J. A. Richman, in United States Letters Patent Number 5,801,356,

patented on September 1, 1998 for "Laser scribing On Glass Using ND:YAG Laser", on the other hand, inscribe or etch the glass carrier in order to provide markings thereon and in doing so may produce unacceptable microscopic cracks in or may otherwise damage the glass carrier.

SUMMARY OF THE INVENTION

It is therefore an object of this invention to provide new and novel apparatuses for applying patterns to carriers.

It is another object of this invention to provide new and novel methods of applying patterns to carriers.

It is yet another object of this invention to provide new and novel apparatuses and methods for applying patterns such as alphanumeric, bar-code, symbology and other markings, upon a carrier, such as glass or the like.

It is still another object of this invention to provide new and novel appparatuses and methods for applying patterns such as strips, stripes and selectively covered areas, upon a carrier, such as glass or the like.

It is yet still another object of this invention to provide new and novel apparatuses and methods for applying markings such as VIN's, and patterns such as electrically conductive paths for defrosting and defogging and for antennae, and selected area coverage for sun shading, and the like, to automobile glass.

It is a further object of this invention to provide new and novel apparatuses and methods for applying patterns to glass carriers such as slides to be utilized for medical, technical, microscope or similar purposes.

It is a further object of this invention to provide new and novel apparatuses and methods for applying patterns to the surfaces of materials which are transparent to selected laser wavelengths.

It is a further object of this invention to provide new and novel apparatuses and methods to automatically apply machine-readable part identification symbol markings to transparent materials using new laser-induced vapor deposition processes. Said symbol markings to be captured and decoded using a reader fitted with a light detector like a charged-coupled device (CCD) or complementary metal-oxide semi-conductor (CMOS) or other technologies such as capacitance, thermal, etc..

It is still a further object of this invention to provide new and novel apparatuses and methods allowing marking processes to be carried out in an open environment and under normal atmospheric pressure and room temperature and which thus eliminate the need for heated, sealed gas/vacuum chambers, and the like.

It is yet still a further object of this invention to provide new and novel apparatuses and methods which enable the application of identification markings to transparent products like glass without the need to generate a marking mask, or the like, to do so.

It is a further object of this invention to provide new and novel apparatuses and methods to apply a relatively thin film coating of contrasting color to a surface, such

coating to be subsequently selectively removed to form a representation of a part identification marking symbol, or text, or other pattern.

It is a further object of this invention to provide new and novel apparatuses and methods to apply a relatively thin film coating to a carrier, such coating exhibiting a difference in density, reflectivity, absorption, or other variance to facilitate the capture and decoding of a part identification marking applied thereto by using an image sensing reader including, but not limited to, capacitance, magneto-optic, micro-power impulse radar, thermal (IR), x-ray, and ultrasound.

It is a further object of this invention to provide new and novel apparatuses and methods to apply to a carrier a symbol which exhibits a difference in density, reflectivity, absorption, or other variance and which may optionally be covered with a coating to hide such symbol from human view for aesthetic or security reasons while permitting the symbol to be captured with a sensing reader to decode and yield human-readable information.

It is yet still a further object of this invention to provide new and novel apparatuses and methods for applying materials to transparent products to create defrosting strips, sun shading, antennas, and circuitry.

Other objects, feature, and advantages, of the invention, in its details of construction, arrangement of parts and methods of operation, will be seen from the above and from the following detailed descriptions of the preferred embodiments when considered in conjunction with the accompanying drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWING

In the drawing:

FIG. 1 illustrates the basic elements of a conventional matrix symbol;

FIG. 2 illustrates the elements of a completed Data Matrix symbol;

FIG. 3 is a detailed view of the part/carrier configuration used to produce markings using the present invention;

FIG. 4 illustrates an apparatus to bring the product and marking provider into position for marking;

FIG. 5 illustrates another apparatus designed to bring product and marking provider into contact for marking;

FIG. 6 illustrates yet another apparatus to place a media containing provider into contact with the part substrate to facilitate marking;

FIG. 7 illustrates a method to improve contrast in markings applied to materials other than glass or similar transparent materials;

FIG. 8 illustrates an alternate marking method involving the removal of portions of a coating to produce a symbol marking;

FIG. 9 details the technique used to mark a laser-induced vapor deposition (LIVD) coated glass substrate.

FIG. 10 illustrates examples of some of the various marking applications supported by the current invention; and

FIG.11 is a schematic illustration of a carrier in the configuration of a slide, incorporating the instant invention, fabricated from a material such as plastic or glass but

one which is transparent to laser wavelengths contemplated herein, and upon which a pattern has been applied employing the process of the instant invention

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The descriptions to follow disclose laser-induced vapor deposition (LIVD) apparatuses and methods to apply graphical representations, human-readable characters, a wide range of different machine-readable symbols, strips, stripes, conductive paths, area coverage and other selected patterns to carriers which are transparent to the wavelengths of the lasers selected for such uses.

The machine readable symbol used as an example herein is a matrix-type symbol. The matrix symbol was developed to overcome many of the deficiencies inherent to the first generation (linear bar codes) and second generation (stacked bar codes) symbol formats. One of the primary changes is the use of data cells as a symbol of data in lieu of the strips of variable widths used in linear and stacked bar codes. The use of a data element of known size and shape makes the matrix code more versatile.

In the matrix code format (FIG 1.), black data cells 20 represent a binary "1" and white data cells 22 represent a binary "0". The basic elements of a matrix symbol are illustrated in FIG.1. Although shown as a square, matrix symbols may also be rectangular. When these binary values are used together in specific sequences, as illustrated in FIG.2, they represent alphanumeric characters. Equal-sized data cells provide for an easier decoding logic decision process than for bar codes. By knowing the size and shape of a symbol and its individual data cells, decoding software can quickly reconstruct damaged

portions of the code. Matrix symbols can be scaled in size to fit into an available marking area.

Matrix codes designed to be applied to any of a variety of articles and products are known and are described in detail, for example, in U. S. Pat. No. 4,939,354 (issued Jul. 3, 1990 to D. G. Priddy, et al.). A matrix code can store from one to 2335 alphanumeric characters in any language. An encoding scheme for use with such a symbol has a high degree of redundancy that permits most marking defects to be overcome. 16-bit cyclic redundancy check and data reconstruction capabilities are included in one version; and Reed-Solomon error correction is included in another. Up to 16 symbols can be concatenated. Error checking and correction (ECC) code 200 is preferred.

FIG. 2 illustrates an example of a Data Matrix symbol 30 which has been placed in the public domain and has been recommended by the American National Standards Institute (ANSI) for use in direct part marking.

FIG. 3 depicts a transparent article or carrier 50, in the form of a glass plate, placed in contact with a marking material or media 52, which has been coated upon a marking media substrate or base 54, and which is utilized, in conjunction with a laser 58, to apply a mark 60 upon carrier plate 50 upon reaction to a laser beam 62 as will be hereinafter described in greater detail. Marking material or media 52 may be otherwise applied to, or carried by, base or substrate 54; the two together forming a convenient media provider 64 for presenting and positioning the pattern marking substance 52 with respect to the intended carrier 50. Any suitable surface may be provided to facilitate positioning of carrier

50 with respect to laser 58; and marking media provider 64 with respect to carrier 50 and so that marking media 52 is in contact with a surface 65 of carrier 50.

The process utilizes a conventionally available heat producing laser (shown schematically at 58 in FIG. 3) such as a Neodymium:Yttrium Aluminum Garnet (Nd:YAG), or Diode Pumped Neodymium-doped Yttrium Vanadate (Nd:YVO4), or other similar laser that is focused on the surface of a marking provider 64 placed in direct contact with a carrier 50 that is transparent to the wavelength of the laser selected for use. Laser 58 may be hand held or fixedly positioned with respect to carrier 50.

The operating program for the selected laser is updated to include the appropriate marking parameters required to vaporize the specific marking media 52, of marking media provider 64, or any selected other optional marking media 52 being used. These parameters include marking speed, frequency (beam pulse), and output power. The laser-marking program is initiated on command by a suitable and conventional operation initiation device, mechanism or program (not shown). Laser beam 62 passes through a near (i. e. nearest to the laser), or first surface 63, of transparent carrier 50 and then passes through far (i. e. furthest from the laser), or second surface 65, of carrier 50 to impinge upon marking media 52. The coaction between laser beam 62 and marking media 52 generates a predetermined heat build-up. When the heat reaches the appropriate selected temperature level, marking media 52 breaks down into a gaseous vapor 66 containing molten droplets 68 of marking material.

Vapor 66 and droplets 68, are however, trapped between two surfaces (i.e. substrate or base 54 and the second, or marking, surface 65 of carrier 50), and condenses on the

cooler marking surface 65 to form a hard uniform coating upon surface 65 which thereafter constitutes mark 60. The thickness of the thin film coating for mark 60 is controlled by adjusting the marking speed, frequency, aperture and power output of laser 58. Media provider marking materials 52 can be varied to provide contrast for optical reading. Material formulations can also be used to support reading using advanced sensing readers designed to detect differences in material density, temperature, capacitance, magnetism or other properties.

If an optional marking media layer is added to media provider 64, such as a film of pure metal applied to a carrier tape, care must be taken to ensure that the vaporization process is confined to the media layer to prevent contamination of the vapor with materials contained in the underlying tape, substrate or base 54.

Marking materials, for media 52, that can be used to support the present invention include, but are not to be limited to, pure metals such as aluminum, chromium, gold, lead, molybdenum, nickel, silver, tin, titanium and tungsten. A wide range of different metal alloys or compounds can also be used to support the process.

Very high quality Data Matrix™ symbols, such as symbol 30 (FIG. 2) have been successfully applied to glass, plexiglass, and plastics materials in the laboratory using a Rofin Sinar Powerline 90 Watt Nd:YAG laser configured for Transverse Electromagnetic Mode (TEM_{00}) operations (160mm lenses and 1.2mm aperture) using 0.016-inch thick metal plates obtained from Damon Company of Salem, Inc. The markings applied contained ten characters of alphanumeric information that were encoded using Error Checking and Correction (ECC) level 200. The 12x12 matrix symbols were created with a laser beam

measuring 0.08mm in width. Ten lines were made to create each data cell with overlapping beam passes. The 8.04mm square symbols contained individual data cells measuring 0.67mm per side. The markings were successfully made using aluminum, brass, copper, and stainless steel plates. Excellent results were also obtained using tin-plate, galvanized plate, and anodized aluminum plates. Tests were also successfully made using 0.076mm thick metal foils obtained from Computype in Minnesota.

The laser settings used in this process were adjusted to obtain optimum results for each provider marking material. Using the laser configuration described above, the following marking parameters were established:

Marking Settings			
Provider Marking Material	Laser Marking Parameters		
	Speed (mm/s)	Power (amps)	Frequency (Hk)
Aluminum	20	16	5000
Black Anodized AL	50	18	5000
Brass	20	17	5000
Copper	20	19	5000
Galvanized Steel	20	15.5	5000
Stainless Steel	50	16	5000
Tin Plate	20	15	5000

FIG. 4 illustrates an automated approach for marking a surface 100 of an article or carrier 102 with a marking media 104 applied to a base or substrate 106 of a flexible marking media provider 108 to facilitate marking using the instant invention. Base or

substrate 106 of flexible provider 108 can be constructed of metal foil, composite ribbon consisting of a metallic layer applied to a polyester film, or other suitable marking media and provider material. Other provider base materials could include paper, cloth and woven or non-woven fabrics or natural synthetic fibers. Flexible provider 108 would ideally be supplied on a spool 120 and threaded under tension rollers 130, over a backing plate 140 and to a take-up spool 150. Transparent carrier plate 102 is passed over the media 104 of media provider 108 and under a laser 160 for marking. The process illustrated in FIG 4. is preferably automated by conventional mechanisms and controls and is driven by a controller that synchronizes the operation of the laser marker, transparent carrier handling mechanism and supply and take- up spools. The process accomplishes marking of carriers 102 as described hereinabove for carriers 50 and utilizes marking media as hereinabove described for the embodiment of FIG. 3. Laser 160, carrier 102, backing plate 140, spool 120, rollers 130 and take-up spool 150 are suitably supported and positioned for coaction as described.

FIG. 5 illustrates another automated apparatus, incorporating the instant invention, that can be used to supply and accurately position marking media providers 200. in the form of discrete plates, under a transparent carrier conveyor 202. Marking media provider plates 200 are reusable, are cut to a desired size and configuration, and each have at least a first surface 204 that carries a marking media 206. Plates 200 are stacked in a gravity fed provider dispenser 210 so that first surface 204 of each provider 200 faces up. Provider plates 200 are successively fed from dispenser 210 by conventional mechanism (not

shown) that feeds media providers 200 onto a provider conveyor 220 with their respective marking media 206 facing upwardly and which passes sucessive provider plates 200 under carrier conveyor 202. Carriers 230, to be marked, on the other hand, are conveyed by conveyor 202 so as to pass over conveyor 220. A marking station 240 is provided where conveyors 202 and 220 intersect. A laser 250, mounted at marking station 240, over the intersection of carrier conveyor 202 and media provider conveyor 220, is directed and controlled to perform a marking operation when marking media 206 carried by first surface 204 of a media provider plate 200 and a marking surface 252 of a carrier 230, to be marked, are properly positioned in juxtaposition to each other. The used/reusable media providers 200 may thereafter be conveyed and routed into a hopper 260 for reuse. During a second, or reuse pass, media providers 200 can be inverted to expose a second or underside surface 262 thereof to laser 250; providing that such underside surfaces 262 have each been provided with an appropriate marking media 264. Adjustments can also be made to the feed from provider dispenser 210 to position unused portions of either surface 206 or 262 of a provider 200 to laser marker 250 and a carrier 230 to be marked. This described process may be fully automated to accommodate high volume manufacturing operations. It should be understood that media for marking of providers 200 and laser 250 are similar to those described above for the embodiments of FIGS. 3 and 4. Laser 250, conveyors 202 and 220, dispenser 210 and hopper 260 are of conventional construction and are supported and positioned for coaction with each other, and coact with each other, by suitable and conventionally available supports and mechanisms and controls.

FIG. 6 illustrates yet another automated apparatus, incorporating the instant invention, that can be used to apply marking media coated labels 310, like those defined in U.S. Patent Number 5,801,356, to the underside 312 of a transparent carrier 320 to be marked. In this embodiment, pre-printed labels 310 are fed to a mechanical applicator 330 via a supply reel 340. The label substrate or backing tape 342 is thereafter taken up on a take-up reel 350. A base blade 352 at the end of applicator 330 presses label 310 firmly against the surface of carrier to seal label 310 onto carrier 312 for subsequent laser marking operations to be carried out as a next step or at a later time but as described hereinabove with reference to the embodiment of FIGS. 3-5. After the marking operation label 310 is removed via mechanical means (by scraping or blowing off) or destroyed using high heat, acid or other desolving agent.

In addition to transparent product marking, the process of the instant invention may improve the contrast level of markings applied to both metallic and non-metallic materials as shown on FIG 7. The improvement in marking contrast is brought about when gaseous residue 410, which may otherwise have been ejected from the marking provider (as shown at A), is trapped between the transparent carrier 420 and substrate 430 and confined within the marking area 440 (as shown at B). The direction of laser is shown by arrow X. Improvements in marking contrast are thus obtained using less power than would normally be applied to a surface to make a mark. This reduction in marking output power results in a marked decrease in surface disruption, which is an important concern for makers of components used in safety critical applications.

Another alternate embodiment of apparatus, which incorporates the instant invention, involves the application of an LIVD patch 450 to a surface 452 of a glass carrier 454 to form a marking surface 456 as illustrated in FIG 8. In this approach, a coating 460 is applied to transparent plate or carrier 454 to form patch 450 that can be subsequently marked as shown, for example at 462 using the same laser and settings as hereinabove described for the previously described embodiments. This process may be otherwise accomplished as set forth hereinafter with respect to FIG. 9.

A transparent carrier 510, with an LIVD coating 512, is positioned atop mounting blocks 520 so as to form an open space 530 between a bottom, or marking surface, 532 of transparent carrier 510 and a work piece 540. A laser beam 550 may be projected through transparent carrier plate 510 to strike the LIVD coating 512 to produce heat. As the temperature rises, LIVD coating 512 is vaporized at selected locations and ejected, as shown at 570, downward from transparent carrier plate 510, forming a representation or representations of a part identification symbol 580 on marking surface 532 of carrier 510. A gap of over ½-inch is maintained between transparent plate carrier 510 and workpiece 540 to ensure that laser beam 550 is out of focus when it strikes work-piece 540 to preclude damage to its surface. Markings 580 produced using this technique or process may be more desirable in some applications because the LIVD coating 512 reduces the amount of glare emanating from the surface of carrier 510 thereby making it is easier to capture and decode with an optical reader.

FIG. 10 schematically illustrates a typical application of the apparatuses and methods described hereinabove as such might be applied to applying identification

markings and selected area coverage to the glass windows for an airplane, automobile or other on or off road vehicle. In this example an airplane 800 includes a windshield or windscreen 802 and a pilots side window 804 as well as a rear seat passenger window 806. Airplane 800 may also be provided with windows for the front and rear seat passanger sides as well as a rear window. A machine readable identification symbol or number (VIN) - alphanumeric or otherwise, has been applied to windshield 802 at 830; while a defrosting strip 832, of conductive material, has been applied to windshield 802 and is otherwise connected to circuitry and controls to effect defrosting of windshield 802. Selected strips or stripes 836, also of electrically conductive material, have been applied to pilot"s window 804 and are electrically connected in suitable circuits to provide an antenna for radio and/or telephone reception. In addition, an upper area of pilots side window 804 has been covered by a sun shading application 840 comprising a plurality of dot-like markings in a predetermined array. The herein described markings, strips, stripes and selected area coverages, have been applied by apparatuses as hereinabove described and utilizing processes as hereinabove described.

FIG.11 schematically shows a carrier 900, in the configuration of a slide, with a marking strip 902 applied thereto and which is to have identification indicia or symbology applied thereto. Such identification indicia or symbology and strip 902 are applied to slide 900 by apparatuses and methods such as those described hereinabove. Slide 900 is fabricated from plexiglass but plastic, glass or other materials, suitable for use as a laboratory slide, or a slide for other research purposes, and which are transparent to the wavelength of the laser to be utilized to apply and mark strip 902 may also be used for

carrier 900. Marking strip 902 has been applied, or coated upon carrier 900, by apparatuses and methods as hereinabove described.

The laser devices for the apparatuses described hereinabove may be fixedly mounted, hand held, or otherwise positioned, to coact with the marking media to mark the carrier parts to be marked. For example, the pattern markings applied (coated) upon windows (as for the schematic airplane of FIG. 10) may be applied to the various windows before the windows are installed in the airplane, automobile or other vehicle. Alternatively the patterns (markings) may be applied to the windows after the airplane, automobile or other vehicle is fully assembled and either prior to its first use or after it has, in fact, been flown, driven or otherwise utilized. To do so one need only position an appropriate laser (with controls) to one side of the window (the side not to be patterned) and a media provider (with appropriate media material) to the other side of the window and up against the window surface. The media provider can be positioned with its media material against the window at the place to be marked by any suitable device or devices. Once the laser beam has been directed through the window and upon the marking media the marking process can proceed as described above for the hereinabove described embodiments.

While the articles or carriers to be marked, as described hereinabove, have been shown and described as glass plates and windows and as plexiglass or plastic slides it should be understood that any carrier may be marked according to the instant invention as long as the carrier is transparent to the wavelength of the heat beam producing device which has been described herein as a heat producing laser. For example colored glass, uncut and cut natural and synthetic gemstones, boules from which synthetic materials and

laser rods are fabricated and the laser rods themselves are just further examples of articles or carriers that may be marked with a pattern according to the instant invention. The patterns to be marked upon such carriers may constitute not only those described hereinabove but may include any configuration of pattern desired and such patterns may be so applied in any selected size including ones that are microscopic in dimension. Furthermore patterns applied to a carrier, as hereinabove described, may be removed from the carrier by vaporization with a heat producing device such as the lasers utilized herein; while marks that are etched or otherwise applied may not be so readily removed.

From the above description it will thus be seen that there has been described new and novel apparatuses and methods for applying numeric, alphanumeric, or other symbology to a transparent part and furthermore for applying strips, stripes and coverage of selected areas for such parts.

Numerous alterations of the structure herein disclosed will suggest themselves to those skilled in the art. However, it is to be understood that the present disclosure relates to the preferred embodiments of the invention, which is for purposes of illustration only, and not to be construed as a limitation of the invention. All modifications, which do not depart from the spirit of the invention, are intended to be included within the scope of the appended claims.

WHAT IS CLAIMED IS:

1. Apparatus for applying a pattern to a carrier, comprising:
   (a) a heat producing laser;
   (b) a support for positioning said laser to project its beam towards and through a carrier when positioned in the path of the laser beam; and
   (c) a marking media provider holder disposed to position the marking media of a marking media provider against a predetermined surface of a carrier when positioned in the path of a laser beam;
   (d) the laser beam, after passing through said carrier, focusing upon a surface of said marking media to vaporize same such that the vaporized marking media condenses upon the predetermined surface to apply a pattern thereto.
2. The apparatus of claim 1 wherein the pattern to be applied to the carrier is to include alphanumeric characters.
3. The apparatus of claim 1 wherein the pattern to be applied to a carrier is to include information recorded in a bar-code configuration.
4. The apparatus of claim 1 wherein the pattern to be applied to a carrier is to include information recorded in a two-dimensional symbology.
5. The apparatus of claim 1 wherein the pattern to be applied to a carrier includes at least one strip of a metal.
6. The apparatus of claim 1 wherein the pattern to be applied to a carrier includes at least one electrically conductive strip.

7. The apparatus of claim 1 wherein the pattern to be applied includes a plurality of electrically conductive strips that are electrically interconnected.

8. The apparatus of claim 1 wherein the pattern to be applied to the carrier includes a predetermined array of markings positioned to facilitate shading from the sun.

9. The apparatus of claim 1 wherein the carrier to which a pattern is to be applied is fabricated from a predetermined material which is transparent to the wavelengths emitted by the laser.

10. The apparatus of claim 9 wherein the carrier to which a pattern is to be applied is fabricated from materials including glass, plexiglass or plastic or combinations thereof.

11. The apparatus of claim 9 wherein the carrier to which a pattern is to be applied is a window.

12. The apparatus of claim 9 wherein the carrier to which a pattern is to be applied is a slide to be utilized for medical, technical or other microscope investigations.

13. The apparatus of claim 9 wherein the carrier to which a pattern is to be applied is a gemstone.

14. The apparatus of claim 9 wherein the material to which a pattern is to be applied is a material from which laser rods are fabricated.

15. The apparatus of claim 1 wherein said heat producing laser is a Neodymium:Yttrium Aluminum Garnet (ND:YAG) laser.

16. The apparatus of claim 1 wherein said heat producing laser is a Diode Pumped Neodymium-doped Yttrium Vanadate (ND:YVO4) laser.

17. The apparatus of claim 1 wherein the marking media may be a metal such as aluminum, chromium, gold, lead, molybdenum, nickel,silver, tin, titanium or tungston.

18. The apparatus of claim 1 wherein the marking medai may be an alloy of metal.

19. A marking device for coating a mark upon an article to facilitate identification of the article or of something associated with the article or to otherwise enhance use of the article or of that which is associated with the article, comprising:

(a) heat producing means for generating a heat producing beam;

(b) support means for positioning an article to be marked in the path of said heat producing beam;

(c) marking means for applying a coating in a predetermined pattern upon a face of an article;

(d) marking means holding means for positioning said marking means against a face of an article when the article is positioned by said support means;

(e) said heat producing beam being positioned and controlled to pass through the article, when the article is positioned by said support means, to impinge upon a marking means, when the marking means is positioned by said marking means holding means, to vaporize at least a part of the marking means;

(f) said vaporized marking means condensing upon and coating the article to apply a mark thereto.

20. The marking device of claim 19 wherein the mark to be coated upon an article is to include alphanumeric characters.

21. The marking device of claim 19 wherein the mark to be coated upon an article is to include information recorded in a bar-code configuration.

22. The marking device of claim 19 wherein the mark to be coated upon an article is to include information recorded in a two-dimensional symbology.

23. The marking device of claim 19 wherein the mark to coated upon an article includes at least one strip of a metal.

24. The marking device of claim 19 wherein the mark to be coated upon an article includes at least one electrically conductive strip.

25. The marking device of claim 19 wherein the mark to be coated upon an article includes a plurality of electrically conductive strips that are electrically interconnected.

26. The marking device of claim 19 wherein the mark to be coated upon an article includes a predetermined array of markings positioned to facilitate shading from the sun.

27. The marking device of claim 19 wherein the article upon which a mark is to be coated is fabricated from a predetermined material which is transparent to the wavelengths emitted by the laser.

28. The marking device of claim 27 wherein the article upon which a mark is to be coated is fabricated from materials including glass, plexiglass or plastic or combinations thereof.

29. The marking device of claim 27 wherein the article upon which a mark is to be coated is a window.

30. The marking device of claim 27 wherein the article upon which a mark is to be coated is a slide utilized for medical, technical or other microscope investigations.

31. The marking device of claim 27 wherein the article upon which a mark is to be coated is a gemstone.

32. The marking device of claim 27 wherein the article upon which a mark is to be coated is the material from which laser rods are fabricated.

33. The marking device of claim 19 wherein said heat producing means is a Neodymium:Yttrium Aluminum Garnet (ND:YAG) laser.

34. The marking device of claim 19 wherein said heat producing means is a Diode Pumped Neodymium-doped Yttrium Vanadate (ND:YVO4) laser.

35. The marking device of claim 19 wherein said marking means may be a metal such as aluminum, chromium, gold, lead, molybdenum, nickel, silver, tin, titanium, or tungston.

36. The marking device of claim 19 wherein said marking means may be an alloy of metal.

37. The method of applying a pattern to a carrier comprising:

(a) projecting a beam of energy along a predetermined path;

(b) positioning a carrier upon which a pattern is to be applied in said predetermined path and so that the beam of energy passes through the carrier;

(c) positioning a marking media against said carrier and so as to be focused upon by said beam of energy as it exits the carrier; and

(d) controlling said beam of energy to produce heat to vaporize said marking media;

(e) said positioning of said marking media against the carrier surface inducing said vaporized marking media to condense indellibly upon the carrier surface in the configuration of said predetermined pattern,

38. The method of claim 37 including configuring the pattern to include alpha-numeric characters.

39. The method of claim 37 including configuring the pattern to include information recorded in a bar-code configuration.

40. The method of claim 37 including configuring the pattern to include information recorded in a two-dimensional symbology.

41. The method of claim 37 including configuring the pattern to include at least one strip of a metal.

42 The method of claim 37 including configuring the pattern to include at least one electrically conductive strip.

43. The method of claim 37 including configuring the pattern to include a plurality of electrically conductive strips that are electrically interconnected.

44. The method of claim 37 including configuring the pattern to include a predetermined array of markings positioned to facilitate shading from the sun.

45. The method of claim 37 including utilizing a carrier fabricated from a predetermined material which is transparent to the wavelengths emitted by the laser.

46. The method of claim 45 including utilizing a carrier fabricated from materials including glass, plexiglass or plastic or combinations thereof.

47. The method of claim 45 wherein the carrier to which a pattern is to be applied is a window.

48. The method of claim 45 wherein the carrier to which a pattern is to be applied is a slide to be utilized for medical, technical or other microscope investigations.

49. The method of claim 45 wherein the carrier to which a pattern is to be applied is a gemstone.

50. The method of claim 45 wherein the material to which a pattern is to be applied is a material from which laser rods are fabricated.

51. The method of claim 37 including utilizing a laser to generate said beam of energy.

52. The method of claim 51 including utilizing a Neodymium:Yttrium Aluminum Garnet (ND:YAG) laser to generate said beam of energy.

53. The method of claim 51 including utilizing a Diode Pumped Neodymium-doped Yttrium Vanadate (ND:YVO4) laser to generate said beam of energy.

54. The method of claim 37 including utilizing a metal such as aluminum, chromium, gold, lead, molybdenum, nickel,silver, tin, titanium or tungston as said marking media.

55. The method of claim 37 including utilizing an alloy of metal.as said marking media.

57. An apparatus for applying a coating to a hard, amporphous, transparent substances made by fusing together one or more of the oxides (silicon, magnesium, calcium, or potassium) that are cooled rapidly to prevent crystallization or transparent mouldable polymeric substances in a prescribed pattern using laser-induced vapor deposition technology.

58. A method for applying a coating to a hard, amporphous, transparent substances made by fusing together one or more of the oxides (silicon, magnesium, calcium, or potassium) that are cooled rapidly to prevent crystallization or transparent mouldable polymeric substances in a prescribed pattern using laser-induced vapor deposition technology.

59. The method of claim 58, wherein a laser is used to vaporize material that condenses on a transparent substrate placed in direct contact with the carrier.

60. The method of claim 58 wherein a thin film coating of contrasting color is applied to a surface that is subsequently selectively removed to form a representation of a part identification markingand wherein said marking is captured and decoded using an optical reader fitted with a light detector like a charged-coupled device (CCD) or complementary metal-oxide semi-conductor (CMOS).

61. The method of claim 58, wherein a thin film coating is applied to a substrate that exhibits a different density, reflectivity, absorption or other variance to promote the capture and decoding of a part identification marking using a capacitance, magneto-optic, micro-power impulse radar, thermal (IR), x-ray, ultrasound or other similar sensing apparatus.

62. The method of claim 58, including positioning a flexible marking media carrier such as a coated ribbon under a transparent substrate in an automated manner to facilitate marking.

63. The method of claim 58 including improving marking contrast on metallic substrates by using lower laser output powerto thus reduce surface disruption.

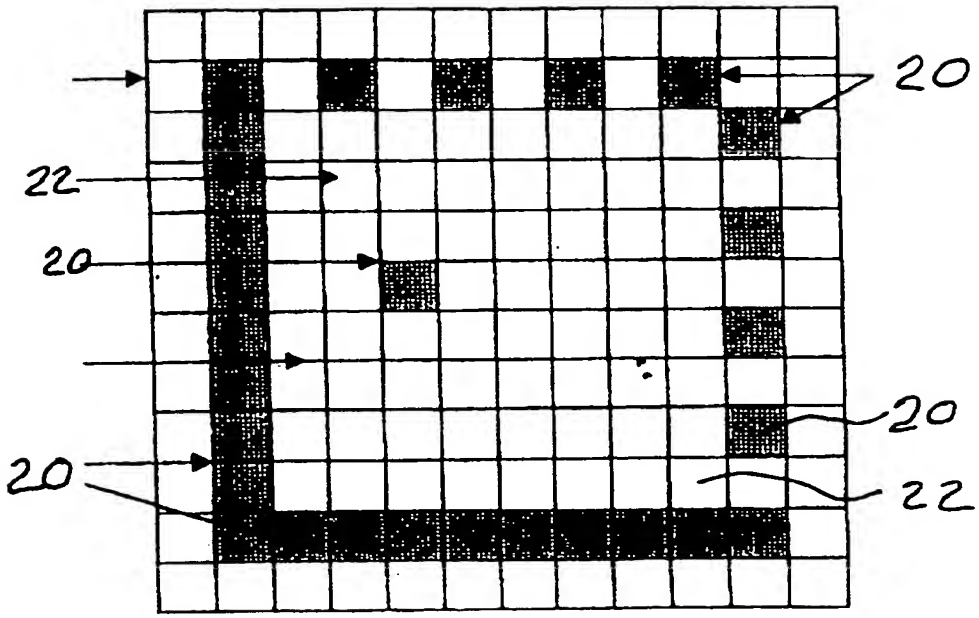

FIG. 1
(Prior Art)

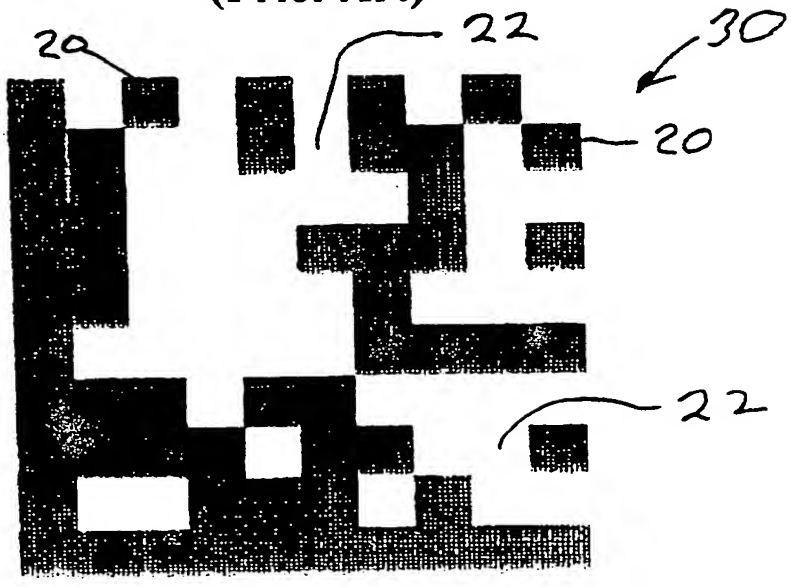

FIG. 2
(Prior Art)

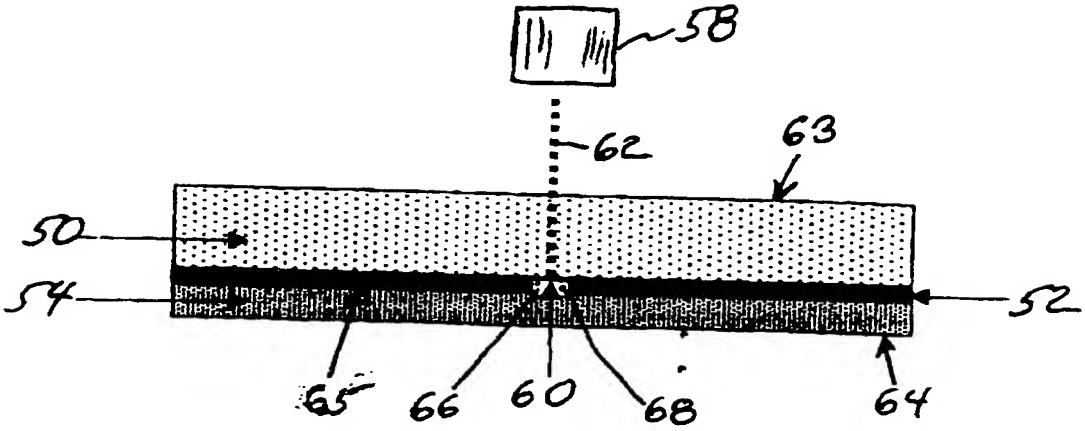
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FIG. 3

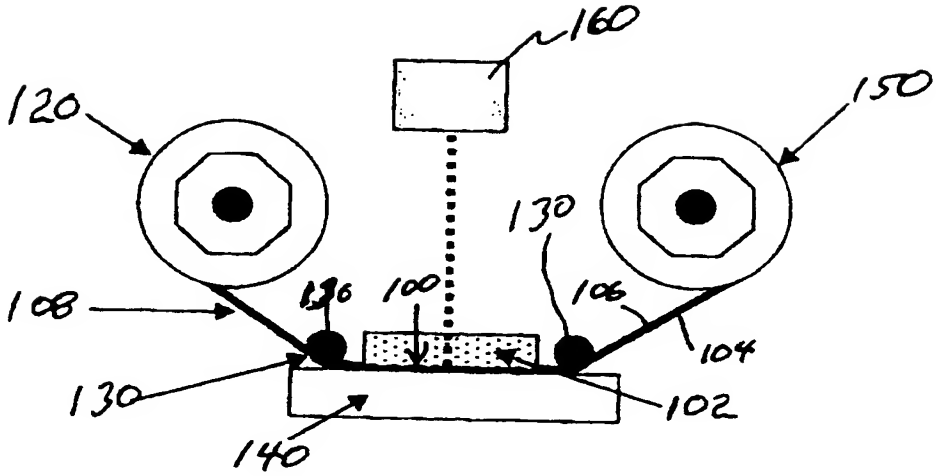
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FIG. 4

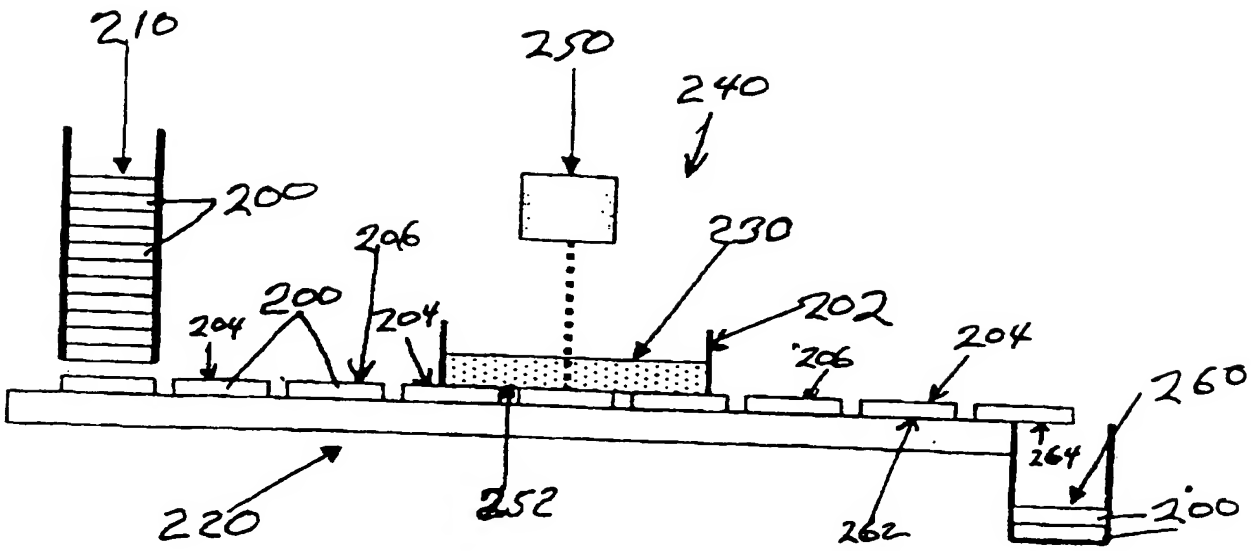
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FIG. 5

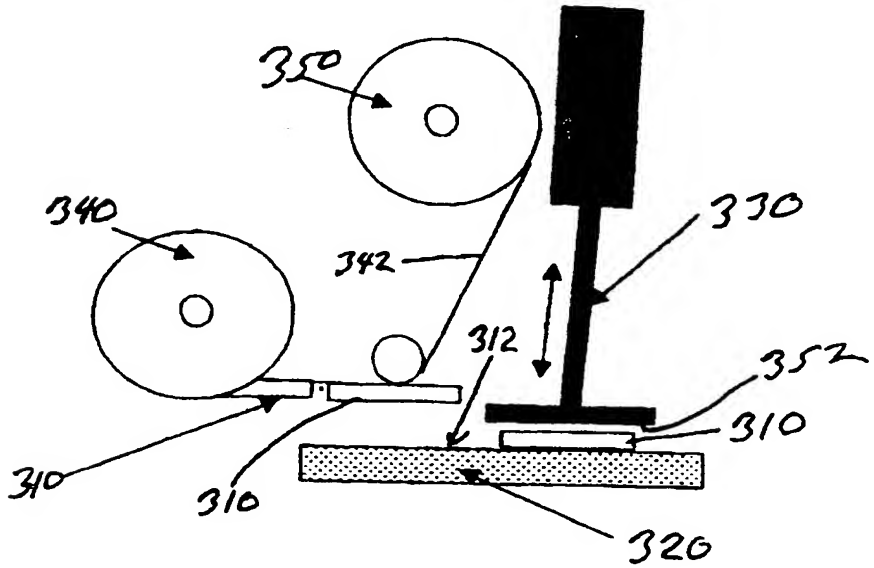
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FIG. 6

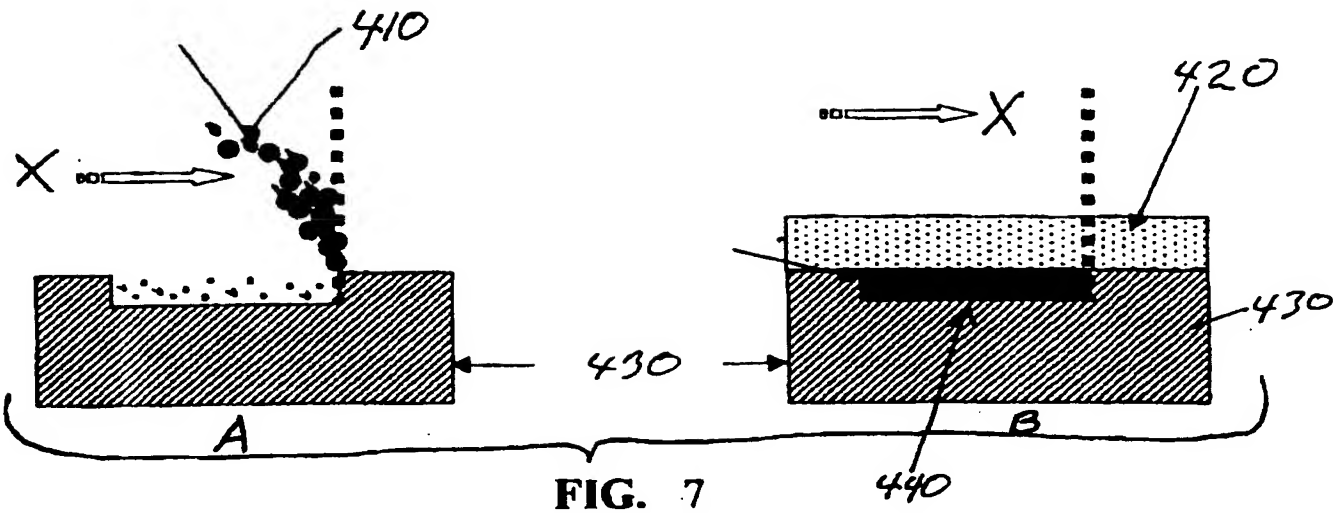

FIG. 7

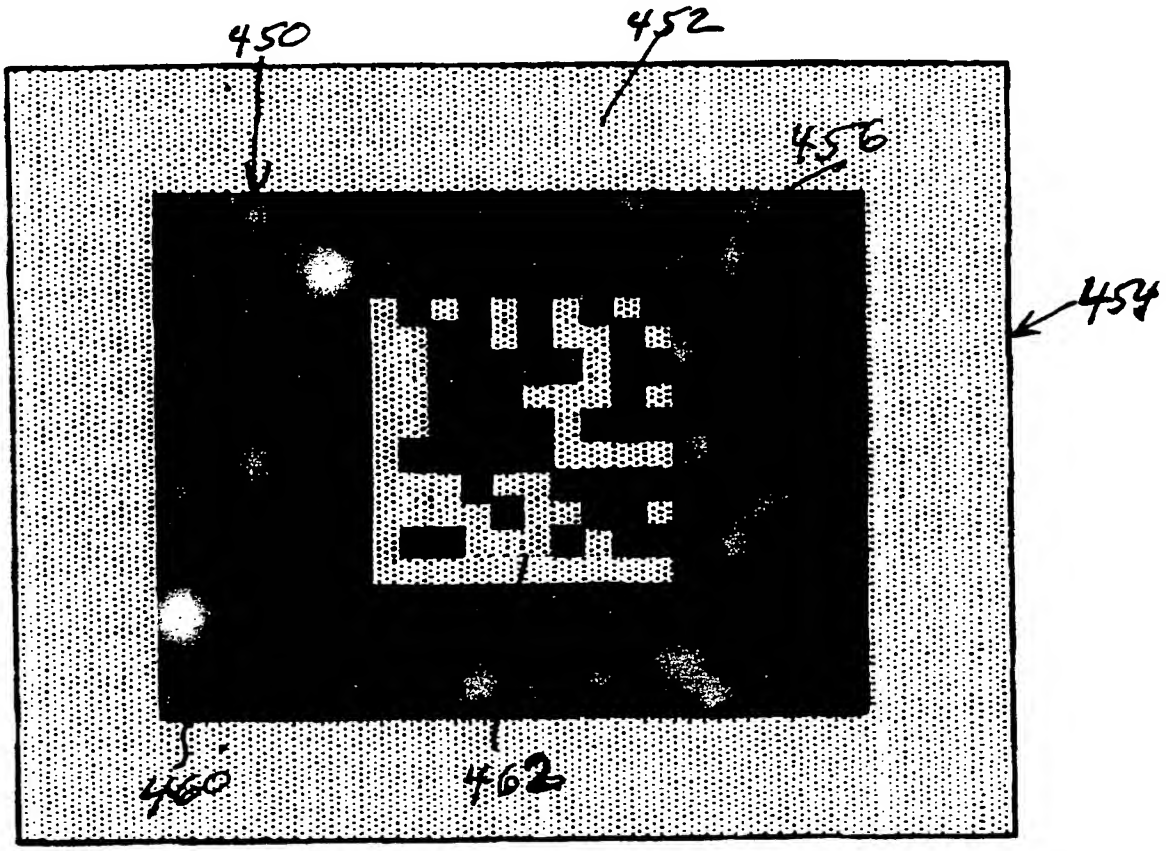

FIG 8

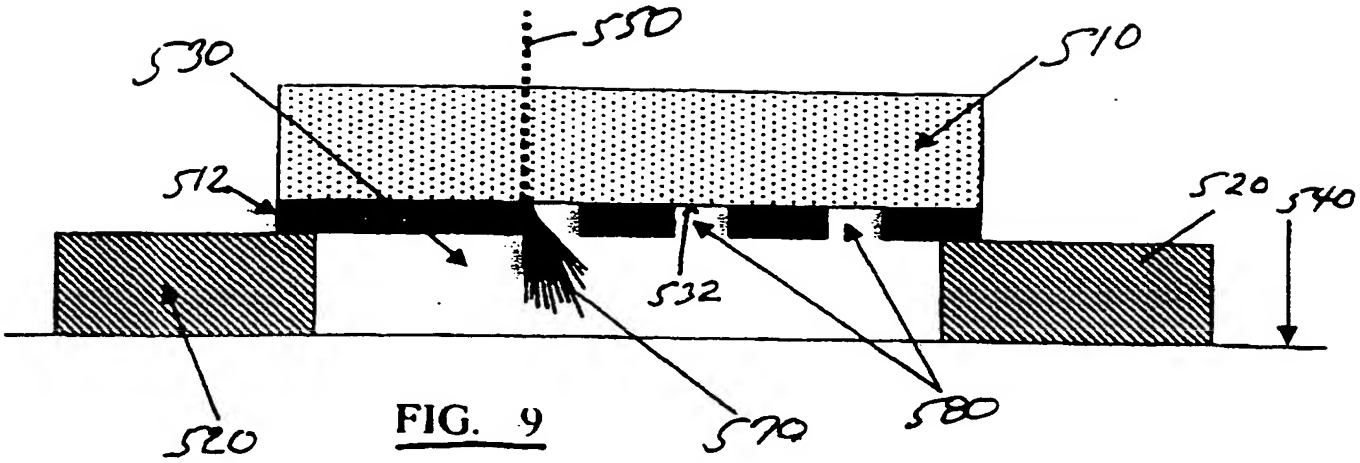

FIG. 9

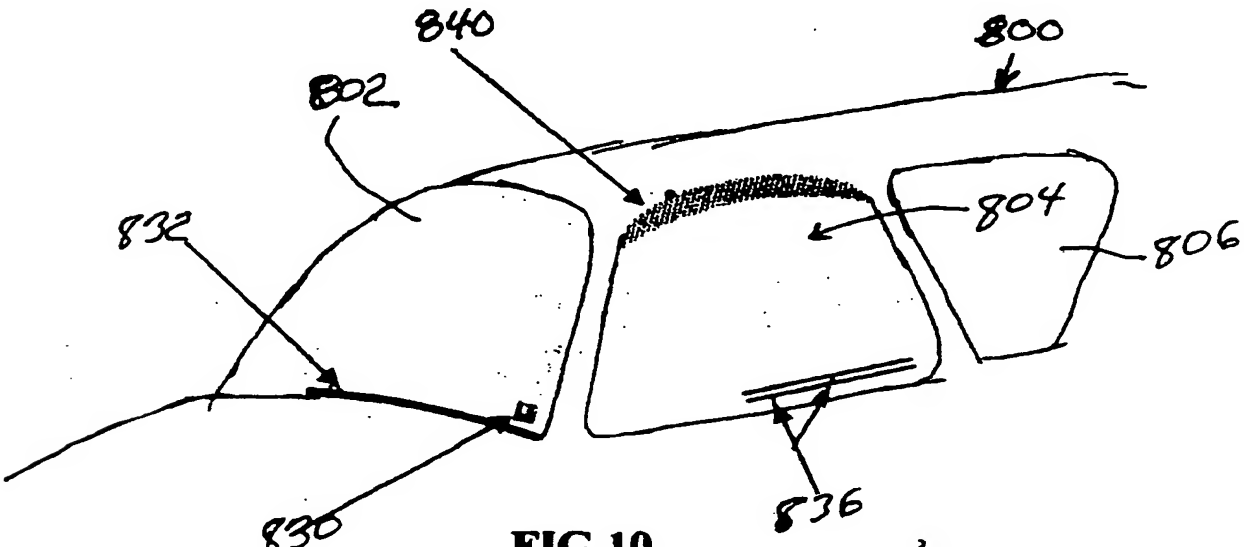

FIG 10

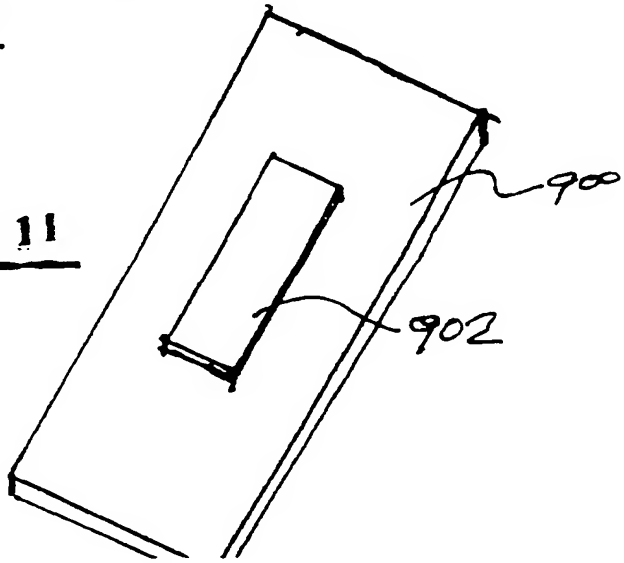

FIG 11

original
Compé

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/17862

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :B23K 26/02
US CL :216/65, 94; 118/722

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 216/65, 94; 118/722

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

http://www.aip.org
search terms & logic: "(laser* <and> mask* <and> (vapor* <or> sublimat*) <and> pattern* <and> metal*)"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,171,650 A (ELLIS et al) 15 December 1992, column 5, lines 21-32; column 14, lines 7-21, 39-44; column 13, lines 24-26, 53-59; column 12, lines 39-45	1,3-12,15, 17,18
Y	US 5,171,650 (ELLIS et al) 15 December 1992, column 14, lines 54-64; column 15, lines 13-19	16
Y	US 5,902,688 A (ANTONIADIS et al) 11 May 1999, Figures 1a,1b; column 4, lines 25-29	2
Y	US 5,410,125 A (WINSTON et al) 25 April 1995, column 1, lines 58-68, 49-56	13

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 12 OCTOBER 2000	Date of mailing of the international search report 14 NOV 2000
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer RUDY ZERVIGON Telephone No. (703) 308-0651

Form PCT/ISA/210 (second sheet) (July 1998)★

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/17862

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 14
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

Claim 14 is vague and does not allow a person of ordinary skill to asertain the scope and context of the claim.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-18

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/17862

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Groups I, claims 1-18 drawn to an apparatus for applying a pattern to a carrier.

Groups II, claims 19-36 drawn to a marking device for coating a mark upon an article.

Group II, claims 37-63, drawn to a method for applying a pattern to a carrier.

The inventions listed as Groups I and III do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The technical feature for creating a pattern on a carrier does not correspond to the same technical feature for the apparatus needed to create a pattern on a carrier.

The inventions listed as Groups I and II do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The technical feature for a marking device applying a pattern to a carrier does not correspond to the same technical feature for the apparatus needed to create a pattern on the carrier.

The inventions listed as Groups II and III do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The technical feature for a marking device applying a pattern to a carrier does not correspond to the same technical feature for creating a pattern on a carrier.